FTI | INTELLIGENCE SPARK

POWER, RENEWABLES & ENERGY TRANSITION (PRET)

eSAF Stands Ready for Takeoff

Aviation has proven to be one of the most difficult subsectors for emissions abatement in the transportation industry. The lack of feasible substitutes for fuel-consuming turbine engines for long-distance travel places great dependence on sustainable aviation fuel ("SAF") for the decarbonization of the sector.

Currently SAF is produced primarily from biolipid feedstock, the supply capacity of which is expected to grow at a much slower rate than needed to fulfill overall biofuel demand growth over the long term. Feedstock constraints for biofuels are a core issue for cost-effective and stable SAF supply. The Power-to-Liquids ("PtL") pathway holds promise for greater emissions reduction and nearly unlimited feedstock capacity; however, to date this approach has been challenged by low technological maturity and a lack of subsidy support as compared to typical biofuel pathways. The Inflation Reduction Act has stepped in with incentives that have the potential to significantly improve the relative economics of electro-SAF or eSAF, kickstarting new eSAF project growth and providing a versatile new source of SAF supply at scale.

Background

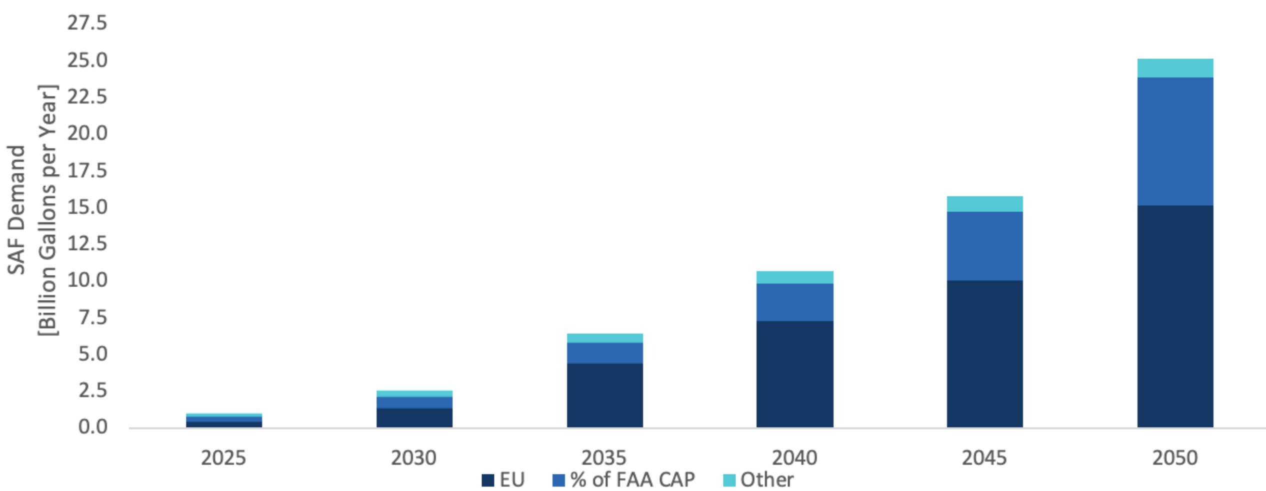
The aviation industry accounts for 10% of emissions in the transportation sector and 3% of the United States' total emissions.[1] A strong outlook for aviation suggests that its contribution to emissions will only increase — Airbus forecasts that over the next 20 years, demand for passenger traffic will record a CAGR of 3.6%.[2]

Efforts toward decarbonizing the aviation sector have developed considerable momentum in recent years. Almost 40 net zero commitments have been made by airlines since 2019.[3] The Federal Aviation Administration ("FAA") pledged a net zero emissions target by 2050 in its climate action plan.[4]

Propulsion technologies with high energy and power density, near-term feasibility and the ability to scale are key to decarbonizing flight. Battery electric and hydrogen propulsion systems are currently not feasible for long-distance flights given the low gravimetric and volumetric energy density of their power sources.[5] SAF, on the other hand, holds the strongest potential for reducing emissions, since it offers a drop-in replacement for fossil fuels and achieves between 80% and 100% reduction of emissions. However, scaling SAF will be challenging, given that production costs are currently 2x-5x the price of fossil jet fuel.

A joint effort between the departments of Transportation, Energy, and Agriculture ("DOE", "DOT", "USDA") created the SAF Grand Challenge, which pledges to increase SAF production to 3 billion gallons per year by 2030 and 100% of demand by 2050.[6] The European Union has taken similar actions with steeper emission reduction targets that are reinforced with volumetric mandates. This combination of market enthusiasm and regulatory support is expected to drive growth in the global SAF Market (Fig. 1) from between $500 million and $950 million in 2023 to nearly $33 billion in 2032, achieving a 45% CAGR during this period of hypergrowth.[7]

Figure 1: Expected Global SAF Demand



Sources: FTI Consulting Internal Demand Model, S&P Global, Federal Aviation Administration.

Note: U.S. demand estimated at 25% of the FAA's Climate Action Plan target.

Constraints Around Biofuel Production

Most SAF production capacity is reliant on biomass-related feedstock such as biolipids from vegetable oils and animal fat, dedicated energy crops, agricultural residues, and municipal solid or wet waste. Because these feedstocks can be used to produce both SAF and renewable diesel using very similar technologies, there is natural competition between SAF and renewable diesel producers over the offtake rights for critical feedstock streams.

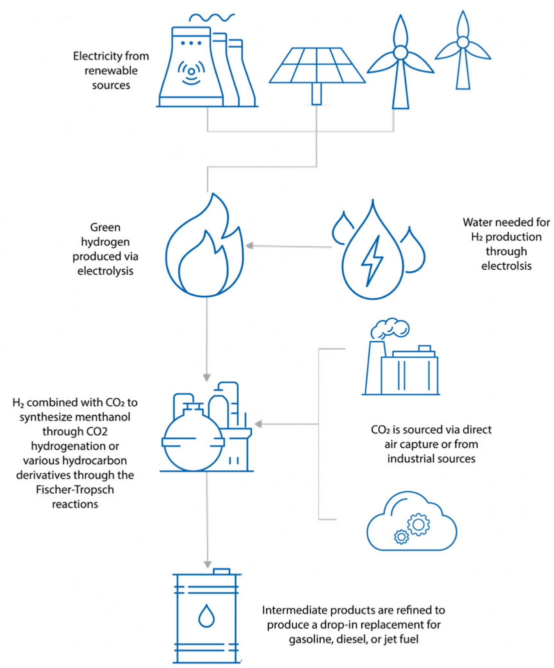
The DOE's recently released 2023 Billion-Ton[8] report projects that there is reasonably attainable biomass volume nationally to meet the needs of the SAF Grand Challenge. However, production of this volume of biomass will require expanded development of energy crops along with increased collection of agricultural waste residues, as well as the development of other new sources of biomass that are not yet commercially available.

Growth in the production of the energy crops needed for biolipid production is associated with many negative externalities such as higher food prices and limited environmental benefits. Energy crops require changes in land use patterns, have high water requirements and compete with other potential crop uses such as human or animal consumption. Bio-waste, on the other hand, has a higher potential for GHG reductions but is considered a limited resource. Bio-waste supplies can only be expanded with improvements in waste collection efficiency at existing waste sources.

The Power-to-Liquid Pathway Allows Production of Electro-SAF at Scale

The PtL pathway enables the production of eSAF using water, electricity and carbon dioxide as raw feedstock. This process offers a superior production method to biofuels with the potential for up to 100% lifecycle emission reduction and no long-term feedstock constraints. However, eSAF production facilities are highly complex and capital intensive, and they incur higher production costs, primarily driven by expensive sources of feedstock.

Figure 2: Illustrative eSAF Production Process

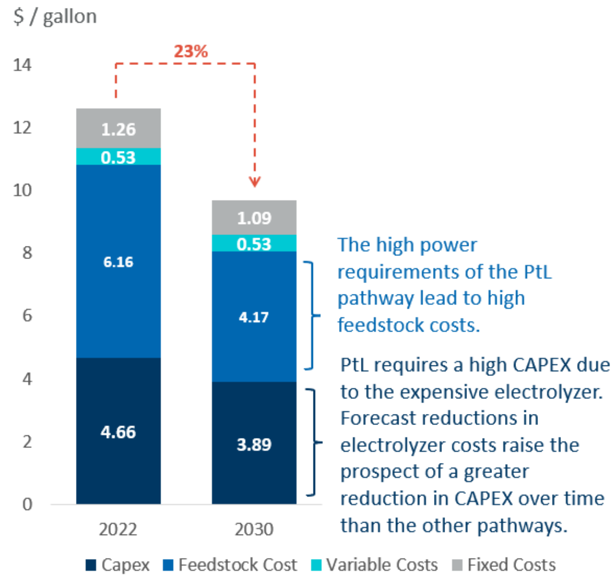


Source: FTI Consulting analysis.

The PtL value chain, as seen in Fig. 2, begins with the production of renewable electricity which is used to produce green hydrogen through electrolysis. Hydrogen is then combined with captured carbon dioxide to produce fuel intermediates such as methanol or direct hydrocarbon products using the Fischer-Tropsch ("FT") reaction. Further refinement through catalytic conversion is needed for both methods to produce drop-in replacements for diesel or jet fuel. The PtL production process depends on multiple emerging technologies with significant growth and regulatory momentum but relatively low technological maturity.

Scaling eSAF depends on advances in four independent industries spanning renewable power, hydrogen, carbon capture and specialized chemical synthesis technologies. The levelized cost of producing eSAF is estimated at ~$7–$12[9] per gallon. As can be seen below in Fig. 3, 40%–50% of the total cost is driven by the levelized cost of procuring feedstocks such as renewable power, hydrogen and carbon dioxide. Developments in these fields are expected to shrink the range of production costs by an estimated 23% by 2030; FTI Consulting's internal cost model projects a cost of $5–$9 per gallon for eSAF at that point. An estimated $3–$4 trillion will need to be spent on infrastructure development by 2050 for eSAF to reach the capacity needed to supplement projected clean fuel deficits.

Figure 3: PtL Pathway with Fischer-Tropsch Production Costs



Note: Assuming cost allocation to all products by volume.
Source: FTI Consulting analysis

The IRA levels the playing field for PtL and eSAF

There are multiple subsidy programs that are applicable to SAF in the United States, such as the Inflation Reduction Act ("IRA") tax credit programs 45Q, 45V and 45Z; the Renewable Fuel Standard ("RFS") at the federal level; and the Low Carbon Fuel Standard ("LCFS") programs at the state level. The RFS requires fixed volumes of bio-based renewable fuels to be blended into fossil fuels for which renewable fuel producers receive credits. The IRA and the LCFS programs offer technology-agnostic incentives based on the lifecycle GHG reduction value or carbon intensity ("CI") of the fuel.

The introduction of IRA tax credits has significantly changed the financial support available for eSAF production; 45V, 45Q and 45Z could each be applied to components of the PtL production process (though they may not be stacked), with 45V and 45Q available for 10 and 12 years of production, respectively. Furthermore, 48C provides a 30% Investment Tax Credit ("ITC") for the refining and blending of renewable fuels. As seen in Fig. 4, the subsidies offer varying degrees of financial support for the production of eSAF, but the cumulative total provides for a substantial boost.

Figure 4: Subsidy Programs Applicable to eSAF

Program		Product Covered	Subsidy	Units per Gallon	Total Subsidy [$/Gal]
IRA	45Z — Clean Fuels [$/Gal]	SAF	$1.25-$1.75	1	$1.25-$1.75
IRA	45Q — Carbon Capture [$/Gal]	PSC DAC	$0.06 $0.13	~11 ~11	$0.66 $1.43
IRA	45V — Hydrogen [$/Gal]	Green H_2	$3.00	~1.5	$4.50
LCFS [$/Tonne CO_{2e}]		SAF	$40-$220	~0.008	$0.32-$1.76
RFS [$/RIN]		SAF	$0.5-$1.65	1.6	$0.80-$2.64

Sources: FTI Consulting analysis, EPA,[10] CARB,[11] Congress. gov.[12]

Section 45Z for clean fuel manufacturing is designed to favor SAF production over other liquid fuels by providing credit of up to $1.75 per gallon for SAF producers while capping the credit value for other liquid fuels at $1 per gallon.[13]

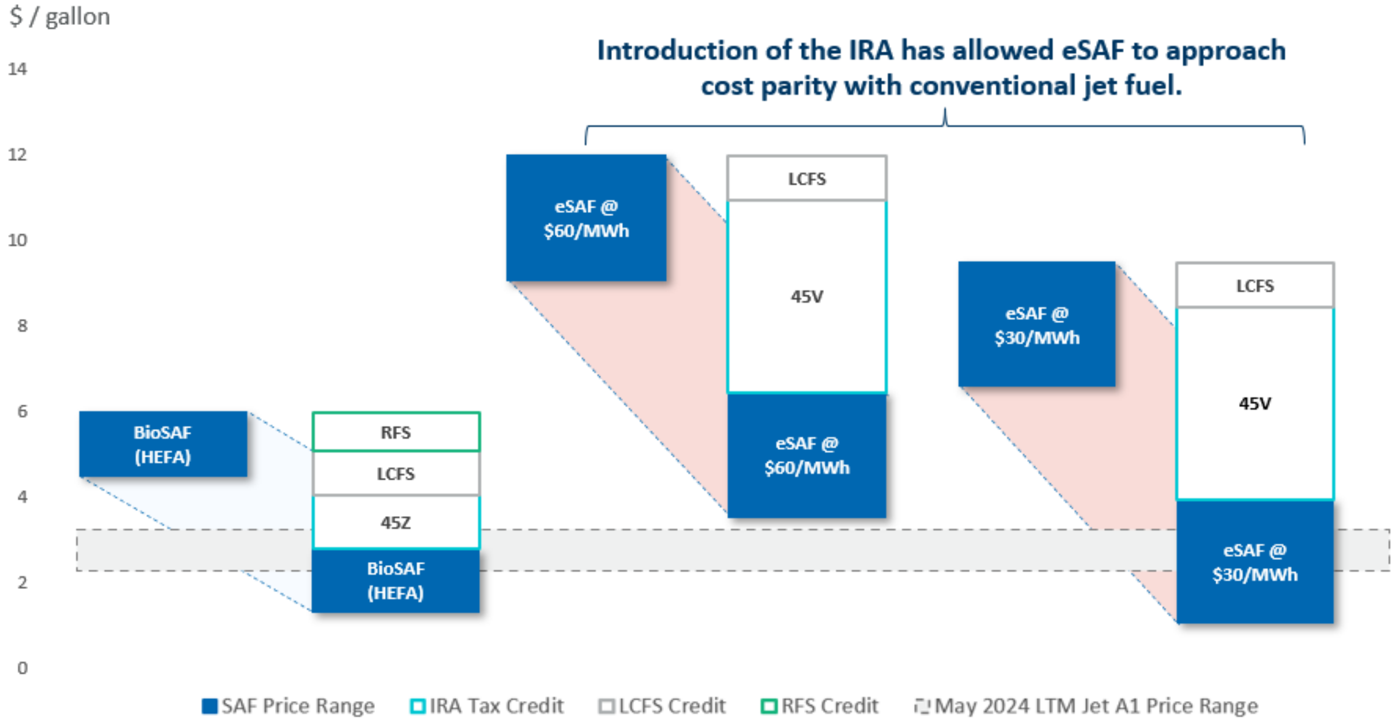
Section 45Q for carbon capture offers up to $60 per metric ton as a base credit, increasing to $130 per metric ton for direct air capture ("DAC") technologies that aim to use the captured carbon in other processes.[14] Each gallon of eSAF requires about 11 KG of CO_2, which results in about $0.66–$1.43 per gallon in production tax credits.

Finally, **section 45V** provides up to $3/kg of clean hydrogen production if the total lifecycle emission of each kg produced is less than 0.45 kg CO_2e. eSAF requires about 1.5 kg of hydrogen to produce a single gallon of eSAF, which equates to $4.50/gal in subsidies under this section. Hydrogen production tax credits are available for 10 production years for projects that begin construction before 2030.[15]

The hydrogen production tax credit 45V represents a 5x increase in the level of subsidies previously available to eSAF producers (as compared to historical access to only the LCFS). Nevertheless, eSAF production is highly sensitive to feedstock costs. The price of power, the primary feedstock component, represents the largest contributor to levelized costs, with each $1/MWh increase incurring a 1% to 5% increase in the Levelized Cost of Production ("LCOP"). CO_2 costs, though supported by Section 45Q, can also vary significantly based on the source and technology used for capture and, because of high transportation expenses, must be evaluated based on proximity to applicable sources.

From FTI Consulting's analysis as shown in Fig. 5 below, prior to the introduction of the IRA — regardless of power prices — eSAF was not within range of being economically competitive with bioSAF or conventional jet fuel. With the introduction of tax credits such as 45Z and 45V, bioSAF and eSAF now are competitive with conventional jet fuel. In particular, 45V provides a substantial amount of value if it can be procured at a competitive power price. At wholesale U.S. LTM power prices between $30/MWh and $60/MWh, eSAF can be cost-competitive with biofuels and conventional jet fuels.

Figure 5: Levelized Cost of SAF Production



Sources: FTI Consulting Internal Cost Model, EPA,[16] CARB,[17] Congress.gov.[18]

Conclusion

Recent carbon mandates have spurred significant momentum in both supply and demand for SAF, which is expected to sustain a whopping 60% CAGR through 2030. eSAF offers a cleaner production method with no long-term feedstock constraints to meet the scale required, but it is expensive and not competitive with other alternatives, such as bioSAF and conventional jet fuel, without sufficient subsidies. The addition of IRA credits such as 45Z, 45V and 45Q, as well as LCFS credits in California, lowers the levelized cost of production of eSAF to a competitive range with biofuel alternatives, potentially kickstarting the growth of this important pathway to producing SAF.

How We Can Help

FTI Consulting's Power, Renewables & Energy Transition practice can deliver holistic, comprehensive solutions across all phases of the energy transition development lifecycle. Specific to the clean fuel space, we have advised clients on projects related to biofuels, eFuels, CCUS, RNG, and clean hydrogen. FTI Consulting has also advised global developers and investors on market entry, as well as in specific engagements across commercial, financial and regulatory dimensions. In addition, we provide expert regulatory analysis to assist project developers and investors navigate the North American and global incentive ecosystem to best position energy transition projects to succeed.

AUTHORS

OSCAR MASCARENHAS
Managing Director
Power, Renewables & Energy Transition (PRET)
FTI Consulting
oscar.mascarenhas@fticonsulting.com

CHRIS FOGLER
Director
Power, Renewables & Energy Transition (PRET)
FTI Consulting
chris.fogler@fticonsulting.com

OTHER KEY CONTACTS

CHRISTOPHER R. LEWAND
Global Practice Leader Power, Renewables & Energy Transition (PRET)
FTI Consulting
chris.lewand@fticonsulting.com

CHRIS POST
Senior Managing Director
Power, Renewables & Energy Transition (PRET)
FTI Consulting
chris.post@fticonsulting.com

JUSTIN PUGH
Senior Managing Director
Power, Renewables & Energy Transition (PRET)
FTI Consulting
justin.pugh@fticonsulting.com

JOHN COCHRANE
Senior Managing Director
Power, Renewables & Energy Transition (PRET)
FTI Consulting
john.cochrane@fticonsulting.com

RJ ARSENAULT
Senior Managing Director
Power, Renewables & Energy Transition (PRET)
FTI Consulting
rj.arsenault@fticonsulting.com

BERTRAND TROIANO
Senior Managing Director
Power, Renewables & Energy Transition (PRET)
FTI Consulting
bertrand.troiano@fticonsulting.com

Endnotes

[1]U.S. Environmental Protection Agency. (2023). Regulations for Greenhouse Gas Emissions from Aircraft. https://www.epa.gov/regulations-emissions-vehicles-and-engines/regulations-greenhouse-gas-emissions-aircraft#:~:text=Aircraft%20covered%20by%20the%20rule,of%20total%20U.S.%20GHG%20emissions.

[2]Airbus SE. (2024). Global Market Forecast 2024.
https://www.airbus.com/sites/g/files/jlcbta136/files/2024-07/GMF%202024-2043%20Presentation_4DTS.pdf.

[3]Nat Bullard. (2024). Annual Presentation 2024.
https://www.nathanielbullard.com/presentations

[4]U.S. Department of Transportation Federal Aviation Administration. (2024). Working to Build a Net-Zero Sustainable Aviation System by 2050.
https://www.faa.gov/sustainability#:~:text=2021%2C%20U.S.%20Transportation%20Sec.,large%20part%20of%20the%20solution.

[5]BloombergNEF. (2022). Decarbonizing Aviation. https://assets.bbhub.io/professional/sites/24/Decarbonizing-Aviation-White-Paper.pdf

[6]Whitehouse.gov. (2021). Biden Administration Advances the Future of Sustainable Fuels in American Aviation. https://www.whitehouse.gov/briefing-room/statements-releases/2021/09/09/fact-sheet-biden-administration-advances-the-future-of-sustainable-fuels-in-american-aviation/

[7]Global Market Insights. (2024). Sustainable Aviation Fuel Market.
https://www.gminsights.com/industry-analysis/sustainable-aviation-fuel-market

[8]U.S. Department of Energy. (2024). 2023 Billion-Ton Report: An Assessment of U.S. Renewable Carbon Resources.
https://www.energy.gov/sites/default/files/2024-03/beto-2023-billion-ton-report_2.pdf

[9]Based on FTI Consulting internal cost model, assumes power costs ranging from $30 to $60 per MWh.

[10]United States Environmental Protection Agency. (2024). Renewable Fuel Standard Program.
https://www.epa.gov/renewable-fuel-standard-program

[11]California Air Resources Board. (2024). Low Carbon Fuel Standard.
https://ww2.arb.ca.gov/our-work/programs/low-carbon-fuel-standard

[12]Congress.gov. (2022). Inflation Reduction Act of 2022.
https://www.congress.gov/bill/117th-congress/house-bill/5376

[13]Ibid.

[14]Ibid.

[15]Ibid.

[16]United States Environmental Protection Agency. (2024). Renewable Fuel Standard Program.
https://www.epa.gov/renewable-fuel-standard-program

[17]California Air Resources Board. (2024). Low Carbon Fuel Standard.
https://ww2.arb.ca.gov/our-work/programs/low-carbon-fuel-standard

[18]Congress.gov. (2022). Inflation Reduction Act of 2022.
https://www.congress.gov/bill/117th-congress/house-bill/5376