Is Sustainable Aviation Fuel (SAF) the Future for Aviation?

And/or are There Alternatives?

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Image Source: World Bio Market Insights

In the US, aircraft are one of the fastest-growing sources of emissions - emissions from aviation have increased 17% since 1990. According to the EPA, aircraft now account for 9-12% of greenhouse gas emissions from the transportation sector. Since transport accounts for 28% of GHG, that means in the US aircraft are responsible for between 2.5% and 3.3% of GHG emissions. (Aviation represents a higher percentage of GHG in the US than worldwide because, in many parts of the world, people fly much less than in the US). With air travel projected to grow rapidly, aviation emissions are expected to roughly double by 2050, both in the U.S. and globally, unless something is done to change that.

But there is clearly a movement to make changes – at both the government and industry levels. One of the major elements of that movement is the introduction of Sustainable Aviation Fuel – or SAF.

What is Sustainable Aviation Fuel?

Sustainable Aviation Fuel is a biofuel used to power aircraft that has similar properties to conventional jet fuel but with a smaller carbon footprint. Depending on the feedstock and technologies used to produce it, SAF can reduce life cycle GHG emissions significantly compared to conventional jet fuel - with reductions of up to 85% having been projected. SAF can theoretically be made from almost any material, including plants, used cooking oil, solid municipal waste, used clothes and even food scraps.

Biomass resources that have been cited as potential sources for SAF include:

- Corn grain
- Oil seeds
- Algae
- Other fats, oils, and greases
- Agricultural residues
- Forestry residues
- Wood mill waste
- Municipal solid waste streams
- Wet wastes (manures, wastewater treatment sludge)
- Dedicated energy crops.

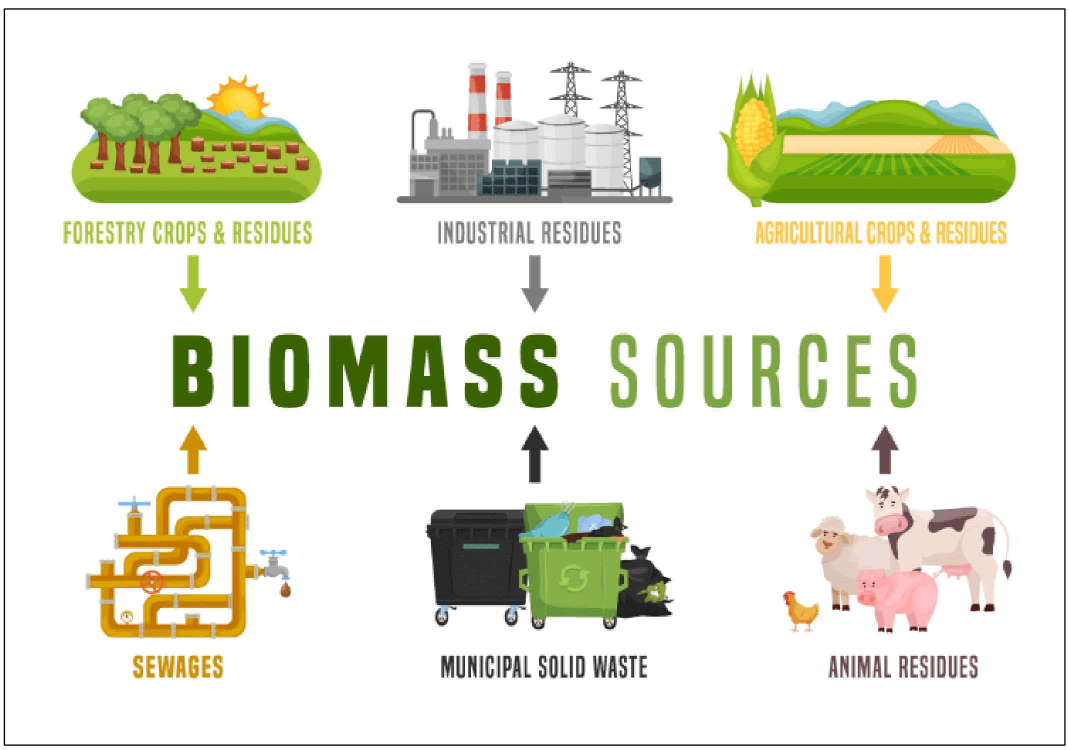

Image Source: electropages

The US Department of Energy (DOE), which has stated that SAF made from renewable biomass and waste resources has the potential to deliver the performance of petroleum-based jet fuel at a fraction of its carbon footprint, has also noted that producing SAF from renewable and waste resources can create new economic opportunities for farming communities. They state that by growing biomass crops for SAF production, farmers can earn more money during off seasons by providing feedstocks to this new market, while also securing benefits for their farms like reducing nutrient losses and improving soil quality. Biomass crops can also control erosion and improve water quality and quantity. They can also increase biodiversity and store carbon in the soil, which can deliver on-farm benefits and additional environmental benefits. Producing SAF from wet wastes, like manure and sewage sludge, reduces pollution pressure on watersheds, and can keep methane gas out of the atmosphere. DOE is working with the US Departments of Transportation and Agriculture, along with other federal government agencies, to develop a comprehensive strategy for scaling up SAF production, as described on the Sustainable Aviation Fuel Grand Challenge web site.

Rosen Aviation, a provider of aircraft cabin displays, inflight entertainment & cabin management systems for both private and commercial aircraft, has argued that investments in SAF production facilities, research and development, and supply chain infrastructure can stimulate economic growth and job creation. and encourage advancements in refining processes, feedstock development and sustainable agriculture practices.

A common question asked is whether Sustainable Aviation fuel is the same as Biofuel. The answer is not necessarily. While SAF falls under the broad category of biofuels, it has specific criteria and requirements that distinguish it from other types of biofuels – and not all biofuels are considered appropriate for SAF.

The key difference is that, as noted above, SAF can be derived from various major feedstocks such as plant oils, agricultural waste, algae and municipal waste. However, not all biofuels used in aviation meet the sustainability criteria necessary to be classified as SAF. SAF requires feedstocks with low carbon intensity and must adhere to specific sustainability targets.

The Roll out of SAF

The first test flight using blended biofuel was in 2008. In 2008 Virgin Atlantic and Boeing completed the first commercial SAF test flight on a 747. In 2011, blended fuels with 50% biofuels were allowed on commercial flights.

By October 2023, Virgin had completed the first cross-Atlantic flight from London to New York with 100% SAF.

Starting a few years ago, the path to SAF has been fueled by regulation.

In 2021, the Biden Administration announced the Sustainable Aviation Fuel (SAF) *Grand Challenge* for the U.S. aviation fuel supply sector to produce at least three billion gallons of SAF per year by 2030 and reduce emissions from aviation by 20%. The long-term goal is to provide 100% of U.S. aviation fuel demand with SAF by 2050. The same year, the European Council released its ***Fit***

for 55 program which is intended to increase the share of sustainable fuels at EU airports from a minimum of 2% in 2025 to at least 63% by 2050.

At the 77th International Air Transport Association (IATA) Annual General Meeting in Boston in October 2021, a resolution was passed by IATA member airlines committing them to achieving net-zero carbon emissions from operations by 2050.

The Inflation Reduction Act (IRA), enacted in 2022, includes a Sustainable Aviation Fuel (SAF) credit which applies to certain fuel mixtures that contain SAF sold or used after December 31, 2022 and before January 1, 2025. The SAF credit is $1.25 for each gallon of SAF in a qualified mixture. To qualify for the credit, the SAF must have a minimum reduction of 50% in lifecycle greenhouse gas emissions. There is also a supplemental credit of 1% for each percent that the reduction exceeds 50%.

Since these actions were taken, the market for SAF has grown dramatically. A January 2024 ResearchandMarkets.com report projected that the worldwide market for SAF will grow from $1.1 billion in 2023 to $16.8 billion in 2030. The report analyzed key players in the SAF space, including *Neste, World Energy, TotalEnergies, LanzaTech, and Fulcrum BioEnergy*. It stated that the growth of SAF has been driven mainly by increased awareness of climate change and the accompanying need to reduce emissions - along with the various regulatory initiatives and mandates. It reported that In 2023 several major airlines committed to what are being referred to as offtake agreements to purchase SAF once it reaches large-scale production. For example, Southwest Airlines made such an agreement for 680 million gallons of sustainable aviation fuel from USA BioEnergy

The report went on to note that North America is leading in terms of SAF adoption because of the regulatory situation. That being said, the report pointed out that SAF still accounts for an extremely small share of overall jet fuel used by airlines, that it has not yet been commercialized at scale, and that prices compared to conventional jet fuel remain high.

According to the International Civil Aviation Organization (ICAO), more than 360,000 commercial flights have used SAF through 2023 at 46 different airports, largely concentrated in the US and Europe.

In July 2024, United Airlines became the first airline to secure SAF for operations at Chicago's O'Hare International Airport. Neste, which is a major producer of sustainable fuels, is committed to supplying up to 1 million gallons of SAF to United at O'Hare in 2024, with initial deliveries starting in August. This extends United's use of SAF to five major airports.

United's *Eco-Skies Alliance program* collaborates with other companies to share the costs associated with SAF; it supported the purchase of over 10.5 million gallons of SAF from 2021 through 2023. The *United Airlines Ventures (UAV) Sustainable Flight Fund* is a key part of United's stated goal to scale up the SAF industry. The fund has received more than $200 million in commitments from more than 20 companies, including competitors (such as Air New Zealand). It invests in startups developing alternative fuels from diverse sources such as algae and agricultural waste.

Image Courtesy of United Airlines

The month after the ResearchandMarkets report cited above was released, in February 2024, the Federal Aviation Administration (FAA) released a "final rule" - *Airplane Fuel Efficiency Certification* - to reduce carbon pollution emitted by most large airplanes flying in U.S. airspace. The rule requires airplanes manufactured after January 1, 2028, as well as subsonic jet airplanes and large turboprop and propeller airplanes that are not yet certified, to incorporate improved fuel-efficient technologies. The rule is part of the *U.S. Aviation Climate Action Plan* that sets out to achieve net-zero greenhouse gas emissions from the U.S. aviation sector by 2050.

Airplanes that will be required to meet the standards include, but are not limited to, the Boeing 777-X and newly built versions of the Boeing 787 Dreamliner; the Airbus A330-neo; business jets such as the Cessna Citation; and civil turboprop airplanes such as the ATR 72 and the Viking Air Limited Q400. The rule does not apply to airplanes currently in service.

Some Recent Approaches to Creating SAF.

Reports have suggested that while the demand for SAF has been growing, the aviation industry has been challenged by limited supplies of traditional SAF feedstocks such as vegetable oils, animal fats and waste oils.

In late 2022, Honeywell announced a new ethanol-to-jet fuel (ETJ) processing technology that allows producers to convert more readily available corn-based, cellulosic, or sugar-based ethanol into sustainable SAF. They reported that, depending on the type of ethanol feedstock used, jet fuel produced from this process can reduce greenhouse gas (GHG) emissions by up to 80% compared to petroleum-based jet fuel. In the announcement, Honeywell cited a 2021 life-cycle analysis by DOE's Argonne National Laboratory which concluded that ethanol-to-jet fuel conversion (combined with other technologies such as carbon capture and sequestration and smart farming practices) would reduce GHG emissions.

Image taken from Honeywell Announcement

Honeywell has claimed that SAF plants using their ETJ technology can be set up off site enabling faster, less labor-intensive installation, and enabling producers to build new SAF capacity more than a year faster than possible with traditional construction approaches.

More recently, in January 2024 to be precise, LanzaJet, a sustainable fuels technology company and sustainable fuels producer, announced the world's first ethanol-to-SAF production facility. The facility, *LanzaJet Freedom Pines Fuels*, is located in Soperton, Georgia and, according to LanzaJet, is intended to produce 10 million gallons of SAF and renewable diesel per year from low-carbon, sustainable and certified ethanol.

In June 2024 LanzaJet partnered with LanzaTech Global (no relation), a carbon recycling company transforming waste carbon into sustainable fuels, chemicals, and materials, to launch *CirculAir™,* a new offering to convert waste, carbon, and renewable power into SAF.

CirculAir is designed to turn nearly any waste source, including municipal solid waste, agricultural residues, carbon emissions from industrial and refining processes, carbon dioxide (through direct air capture), and renewable power into SAF. CirculAir combines LanzaTech and LanzaJet's technologies, incorporating LanzaTech's novel gas fermentation technology to convert nearly any waste resource into CarbonSmart™ ethanol and then executing LanzaJet's Alcohol-to-Jet (ATJ) technology by taking the ethanol and converting it to drop-in SAF. The SAF made through this process is projected by its developers to reduce aviation emissions by at least 85%.

But Not Everyone Seems to be a Fan of SAF

While SAF appears to have achieved significant traction and to be highly regarded, it has detractors as well.

Perhaps most prominently, in a May 2024 article, the **World Resources Institute (WRI)** argues that many scientists and international regulatory bodies have concluded that growing crops to make aviation fuel *does not* reduce emissions on a full lifecycle basis (from crop production through to processing and consumption) because it displaces food crops, which drives the expansion of cropland into forests and grasslands to compensate for lost food production. Converting forest or grassland to cropland releases stored carbon and severely reduces future carbon sequestration on that land.

The article continued, noting that 1.7 gallons of corn ethanol are needed to make 1 gallon of SAF. For the US to reach its goal of 35 billion gallons of SAF, using ethanol - currently the leading approach – would require 114 million acres of corn – which is 20% more than the total US currently planted with corn for all purposes. It does acknowledge that ethanol production generates some useful by products, such as animal feed, which would otherwise be made with purpose-grown crops. However, even after accounting for this, the article argues that the overall increase in corn demand would ultimately drive-up food prices - and result in less corn available for food.

WRI also states that SAF made from soy oil would likely have an even bigger impact because soy is less efficient than corn at producing ethanol. Further, there is one interconnected global market for vegetable oil and most new production comes from the expansion of oil palm and soybeans in the tropics, where they are major drivers of deforestation. If just ¼ of the world's aviation fuel likely needed in 2050 were to come from vegetable oil, its production would need to double globally.

Image of a cleared corn field in front of an ethanol plant in Portage, Wisconsin. Courtesy WRI

The article continues by asking where emissions models got it wrong. It notes that the IATA defines sustainable aviation fuel as fuels that reduce CO_2 emissions by up to 80% compared to conventional jet fuel and are made from feedstocks that "do not compete with food crops or output, nor require incremental resource usage such as water or land clearing." (Rosen Aviation, cited earlier, has also stated that SAF cannot be made from anything that diverts land use from food crops, destroys forests or consumes too much fresh water, as that's simply not sustainable and defeats the purpose of alternative fuel).

The IRA's SAF tax credit is also tied to effectiveness; as noted earlier it starts at $1.25 per gallon for SAF that reduces lifecycle greenhouse gas emissions by at least 50% compared to conventional jet fuel and increases by an additional 1 cent per gallon for each percentage point of emissions reductions beyond this threshold. So how should the full lifecycle emissions from producing and burning aviation fuel be calculated?

The IRA references a model adopted by the International Civil Aviation Organization (ICAO) that satisfies the criteria established by the US Clean Air Act. The US Treasury's recent guidance – which followed lobbying by the ethanol industry - allows for the use of an alternative model, a version of *Greenhouse Gases, Regulated Emissions, and Energy use in Technologies* (GREET) released in 1995, which opens the door for corn ethanol and other crop-based biofuels to qualify for the credit. Major US airlines supported the ethanol industry's push despite previously agreeing that SAF production should not compete with food production.

WRI argues that while much of the discussion surrounding the SAF tax credit has focused on which model should be used to estimate airline emissions, what is more important are the assumptions incorporated into a given model — in particular, how it accounts for the impact of dedicating farmland to fuel production rather than food production. Furthermore, models which suggest that "indirect land-use change" emissions are small compared with petroleum emissions often underestimate the amount of new land needed to grow food and may be assuming that poor people will simply eat less because food prices rise when crops are diverted to fuel production. Other models make assumptions like no forests will be cleared to replace the cropland used for fuel, despite the fact that an average of more than 3 million acres of forests are being cleared each year to make room for expanded palm and soybean oil production.

WRI argues further that a more straightforward approach is to consider the following "thought experiment": If there really are millions of acres of prime farmland that aren't needed for food production, what would be the best use of that land to mitigate climate change? Their answer is that avoiding additional deforestation and restoring forests to previously cleared land is 2-4 times more effective at curbing climate change than turning food into fuel over a 30-year period.

The WRI article goes on to say that scaling up carbon removal technology to compensate for the emissions from burning 35 billion gallons of petroleum-based jet fuel would require much less land than replacing it gallon-for-gallon with crop-based fuel. If, for example, direct air capture (DAC) technology powered by solar energy were used to remove 434 million $MtCO_2$ per year — the amount that would result from 35 billion gallons of petroleum jet fuel — it would require around 3.7 million acres of land. The amount of land needed to replace the same volume of fuel with corn ethanol is around 30 times higher – they claim.

WRI offers the following as options to address sustainable aviation fuel:

- Restrict biofuel production to waste biomass. Plant material left over after harvesting crops and lumber, as well as municipal wastes, have the potential to supply a truly carbon-negative biogenic fuel, particularly when the processing of these fuels is coupled with carbon capture and storage technology. However, the amount of waste biomass available would only produce a portion of total aviation fuel; estimates of waste range from supplying ~5% of European aviation fuel demand in 2030 to ~20% of US aviation fuel demand in 2050.
- Explore synthetic e-fuels, also known as "power-to-liquid fuels", such as e-kerosene which can be produced from captured carbon and green hydrogen. Europe's SAF mandate requires that at least 2% of aviation fuel come from synthetic fuels by 2030. Current challenges to expanding the use of synthetic fuels include the high cost and obstacles in scaling production.
- Use batteries to power short flights. Batteries that would be needed for long-haul flights are currently too heavy, but battery-powered short-range flights have already been proven viable. More on this to follow
- Support development of hydrogen-powered flights. Green hydrogen could be the ultimate solution for aviation if fuel handling and storage challenges can be resolved. More on this to follow as well.

The reality is that WRI's opinions are in the minority, and US agencies such as DOE and DOT do not appear to abide by what they have to say. However, CRI definitely has raised multiple important issues that should be carefully considered as companies plan to produce SAF.

Sustainable Alternatives to SAF?

As suggested in the last section, there are potentially some alternatives to the type of Sustainable Aviation Fuels described above, which could potentially be even more sustainable. As will be discussed, there is still a ways to go to make these alternatives cost-effective.

<u>Hydrogen-Powered Planes</u>

The first alternative to discuss is Green Hydrogen – which is hydrogen generated from water using electrolysis powered by renewable energy.

There are currently 2 approaches being pursued for hydrogen fuel for transportation:

- A *hydrogen internal combustion engine vehicle (HICEV)* uses an engine very similar to a gasoline or diesel engine – but fueled by hydrogen.
- *A fuel cell hydrogen vehicle (HFCEV or FCEV)* generates electricity from hydrogen via a fuel cell and uses that electricity to power an electric motor, much like in an electric

vehicle. Hydrogen fuel cells generate electricity through an electrochemical reaction between hydrogen and oxygen, which combine to generate electricity, heat, and water.

Both approaches are being looked at by the aviation industry.

In 2020, Airbus unveiled its ZEROe concept, potentially the world's first hydrogen-powered commercial aircraft, which it hopes to bring to market by 2035. Airbus is adapting its A380 MSN001 test aircraft to be the prototype for the ZEROe program. The aircraft will still use conventional engines for propulsion but provide a flight environment to test hydrogen systems. Airbus plans to create a 200-seat, 2,300-mile range hydrogen combustion airliner, but will start with a 100-seat, 1,150-mile range aircraft, which they expect to be available by 2035. They are working on both Internal Combustion and Hydrogen Fuel Cells but are currently focused primarily on the former. To address fuel cells, Airbus established a joint venture - Airbus Aerostack - with automotive supplier ElringKlinger AG to develop hydrogen fuel cell stacks.

Since unveiling ZEROe, Airbus has also partnered with Avinor, SAS, Swedavia, and Vattenfall to investigate the feasibility of hydrogen infrastructure at airports in Sweden and Norway. The companies signed an agreement to execute their plan, with the aim of better understanding hydrogen aircraft concepts and operations, supply, infrastructures, and refueling needs at airports needed to build a hydrogen ecosystem. The companies have a shared ambition of the aviation industry reaching net-zero carbon emissions by 2050.

According to Airbus, hydrogen is a potential alternative to decarbonize the aviation industry, since it has a specific energy-per-unit mass that is three times higher than traditional jet fuel. Green Hydrogen can potentially power large aircraft over long distances without emitting any carbon.

The partners will conduct a feasibility study covering two countries and more than 50 airports, and work to identify pathways to enable airports to operate hydrogen-powered aircraft - and to implement the accompanying necessary regulatory framework.

"Hydrogen stands out as a key enabler as we pioneer a sustainable aviation future," Guillaume Faury, CEO of Airbus, said in a statement. "Norway and Sweden are among the most demanding regions for aviation and have great potential for hydrogen production from renewable energy sources. I am very pleased to enter into this cooperation with partners fully engaged to take significant steps towards decarbonizing aerospace. It fits perfectly with our strategy of deploying hydrogen aviation ecosystems in the most suitable parts of the world."

Below are images – with additional information - from the section of Airbus' website addressing ZEROe.

Airbus Hyrdrogen Powered Aircraft Concepts

Turbofan

Range: 2,000+ miles | Passengers: <200

Two hybrid-hydrogen turbofan engines. Liquid hydrogen storage and distribution system located behind rear pressure bulkhead.

Turboprop

Range: 1,000+ miles| Passengers: <100

Two hybrid-hydrogen turboprop engines, which drive eight-bladed propellers. Liquid hydrogen storage & distribution system located behind rear pressure bulkhead.

Blended-Wing Body (BWB)

Range: 2,000+ miles | Passengers: <200

Two hybrid-hydrogen turbofan engines. BWB wide interior opens up multiple options for hydrogen storage & distribution. Liquid hydrogen storage tanks located underneath the wings.

Fully Electrical Concept

Range: 1,000 miles| Passengers: <100

Fully electrical concept revealed in Dec. 2020. Based on fully electrical propulsion system powered by fuel cells.

Airbus is not the only company looking at hydrogen. Startups **H2FLY** and **ZeroAvia** are developing smaller aircraft powered by hydrogen fuel cells in a much shorter timeframe. In 2020, ZeroAvia successfully flew a six seat Piper Malibu with a 250kW hydrogen-electric propulsion system and is poised to test a 600kW-equipped, 19-seater Dornier 228 (image on the right).

ZeroAvia aims to certify its 600kW powertrain so it can be used in 9 to 19 seat aircraft by 2025 – the same timescale within which H2FLY expects to start operations with its 300kW five-seater aircraft. H2FLY's aircraft will use technologies proven on the company's HY4 hydrogen retrofitted Pipistrel Taurus G4 glider, first developed at the German Aerospace Centre.

In parallel, both H2FLY and ZeroAvia are working on upscaled 2MW powertrains as well.

The ResearchandMarkets report cited earlier stated that "the hydrogen fuel cells segment leads the sustainable aviation fuel (SAF) market with its high energy density, offering an efficient and effective solution for powering aircraft. Additionally, hydrogen's versatility and compatibility with existing aircraft infrastructure further solidify its position as a key player in driving the transition toward greener aviation". There are clearly a number of issues with this statement. First of all, hydrogen fuel cells cannot really be classified under the definition of SAF described earlier that is generally understood. In fact, an Energy & Environment Leader article in August 2024 that reported on United's introduction of SAF at O'Hare went on to say: "***In addition to promoting SAF***, United is exploring hydrogen powered flight technologies, enhancing operational efficiencies, and investing in new fuel-efficient aircraft". In other words, Hydrogen Fuel is not being considered part of SAF.

Secondly, as noted above, aircraft manufacturers are clearly in the very early stages of developing hydrogen-fueled aircraft.

And, finally, Green Hydrogen remains a very expensive fuel, so until we see the price point come down significantly, we cannot expect airlines to adopt hydrogen fuel at a significant level.

That being said, Green Hydrogen costs are coming down, so we can expect hydrogen to play a major role in making the aviation industry more sustainable at some point in the not too-distant future.

Methanol as an Aviation Fuel

There are currently 2 sources of what is referred to as Green Methanol – which does not release CO_2 (or methane). The first – biomethanol – is produced from the gasification of sustainable biomass sources, such as livestock and agricultural residues. Which sounds quite similar to SAF. The second, e-methanol. is produced from green hydrogen and CO_2.

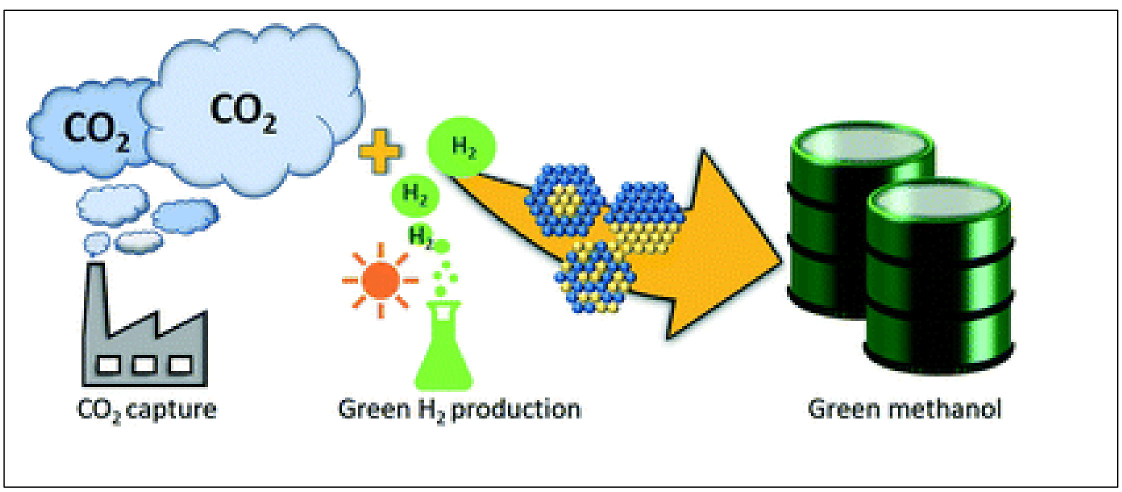

Image Source: RSC Publishing

Green Methanol is becoming a potentially significant *maritime* fuel for a number of reasons. Because it is a liquid at room temperature, it is much less costly to store and transport than gaseous fuels and has the lowest carbon footprint of all liquid fuels. It can also be used in both internal propulsion engines and to power fuel cells, providing flexibility. Since Green Methanol is chemically identical to conventional methanol, there are no compatibility issues or further engine investments required of shipping companies, allowing a seamless, gradual transition from conventional to Green Methanol. It is also compatible with current methanol dual-fuel engine technology. Methanol also has a higher volumetric energy content than alternative clean maritime fuels like ammonia, making it a better choice for a wide range of vessel types and longer voyages. (It is also less toxic than ammonia). Green Methanol can potentially enable the industry to meet the International Maritime Organization's decarbonization goals.

Methanol is currently available at more than 125 of the world's largest ports. Industry interest in methanol as a marine fuel is rapidly growing, leading to commitments from some of the world's largest shipping companies to purchase methanol from companies such as Methanex, which is the world's largest producer and distributor of methanol. The major shipping line Maersk has committed to introducing 19 container ships by 2025 that run on e-methanol (they may also be able to run on biodiesel). Maersk has also agreed to buy half a million tons of hydrogen-based and biogenic Green Methanol per year from Chinese wind farm Goldwind.

One hurdle with Green Methanol is cost – it can be 3-4 times as expensive as diesel-based marine fuels. Hopefully those costs can be reduced significantly over the next few years.

But can Green Methanol be an effective aviation fuel?

There are several companies – including ThyssenKrupp (a German industrial engineering and steel production conglomerate) – looking into whether Methanol can be a Sustainable Aviation Fuel.

The problem is that methanol may not be practical for aviation because it has a low energy density compared to other fuels. Planes using methanol would be severely limited in range because of the weight of the fuel they would need to carry.

Moreover, the American Society for Testing and Materials (ASTM International) has not certified methanol as an acceptable aviation fuel. Jet fuel must comply to quality specifications to be eligible for use in the aviation industry. The ASTM D1655 "Standard Specification for Aviation Turbine Fuels" is the global basis for jet fuel quality specifications.

Nonetheless, in October 2022 ExxonMobil Chemicals announced a Methane to Jet Fuel option. ExxonMobil stated that methanol derived from the gasification of biomass and waste, as well as from lower-carbon hydrogen and captured carbon dioxide, can be converted into SAF using their proprietary methanol to jet process technology and catalysts. ExxonMobil claimed that this solution has a higher yield of jet fuel than other options. They also stated that the solution provides the flexibility to use a mix of alcohols as feedstock and produce renewable diesel and lower-carbon chemical feedstocks.

Much more recently, at COP28 in Dubai in late 2023, TotalEnergies, a French multinational integrated energy and petroleum company, and Masdar (also known as the Abu Dhabi Future Energy Company), an Emirati state-owned renewable energy company, demonstrated a successful test flight where methanol was converted into aviation fuel. The UAE General Civil Aviation Authority, Airbus, Falcon Aviation Services, and Axens (whose self-described aim is to enable the conversion of oil and biomass to cleaner fuels) all contributed to this project.

The flight used a blend of aviation fuel made from olefins. (Common olefin examples include propane, ethene, butene, and pentene). The Alcohol-to-Jet Synthetic Paraffinic Kerosene pathway (ATJ-SPK) was certified in 2016 as meeting international standards for jet fuel. However, Methanol is not in the list of specified alcohols.

The CEO of Total Energies made the following statement after the test flight: “TotalEnergies is delighted to have initiated this scouting effort together with Masdar. As industry and energy companies, our collective job is to work on the next generation of clean aviation fuels that could complement SAF currently produced from used cooking oil. This novel pathway to jet, through e-SAF, is critical to support the decarbonization of the aviation industry”,

What is unclear at this point is exactly how renewable the fuel demonstrated at COP28 was, what the energy density was, and how expensive it would be to create this fuel for mass adoption.

Bottom line; multiple organizations are clearly working on transforming methane into a Sustainable Aviation Fuel, but methanol would appear to currently be far behind hydrogen on the quest for SAF.

<u>Electric Planes</u>

As the final option to explore here, let’s take a look at the potential for electric planes.

An Electric Plane is an aircraft fully powered by electricity. Instead of jet fuel, these planes are now typically outfitted with rechargeable lithium-ion batteries and electric motors. Running on electricity not only makes aviation more sustainable, but also reduces noise pollution. (On the downside, lithium-ion batteries can account for more than half a plane’s weight).

Since electric aviation is still in its infancy, it’s impossible to pinpoint average flight times or distances; companies are currently just starting to conduct experimental test runs or working their way up to it. Most current prototypes – some of which are hybrid electric - can manage trips under 1,000 miles.

The record for distance traveled by an electric plane is held by Solar Impulse’s Solar Impulse 2, which traveled over 5,000 miles non-stop from China to Hawaii during the round-the-world solar flight in 2015 and 2016. But this was a solar powered – not battery-powered aircraft. Which is a whole other story.

In 2023 Beta Technologies demonstrated the all-electric, battery-powered CX300 on a 16-day flight along the East Coast. The plane flew over Boston, New York, Washington and other cities and made more than 20 stops along the way – but not for refueling. After the trip ended – in Florida - Beta handed the plane off to the Air Force for further experimentation.

CX300 – Image Courtesy of Beta Technologies

Beta has raised more than $800 million from investors including Fidelity, Amazon's Climate Pledge Fund and others. The company employs about 600 people, mostly in Vermont, and recently finished building a factory in Burlington where it plans to mass produce its aircraft, which have yet to be certified by the FAA.

The CX300 has a 50-foot wingspan, large, curved windows, and a rear propeller. It is designed to carry about 1,250 pounds of cargo. Beta plans to follow the release of the CX300 with the A250, which shares about 80 percent of the CX300's design. A key difference; the A250 is outfitted with lift rotors to take off and land like a helicopter. Both aircraft, which Beta refers to as the Alia, are intended to eventually carry passengers.

Beta is just one of multiple companies working on electric aviation. In California, Joby Aviation and Archer Aviation are developing battery-powered aircraft that, they say, will carry a small number of passengers over short distances. Those companies' backers include Toyota, Stellantis, United Airlines, and Delta Air Lines, as well as large investment firms. Several aircraft manufacturers - including Airbus, Boeing and Embraer - are also developing their own electric aircraft.

Some Fun Renderings of Electric Airplanes

Source: MIT Technology Review

Source: NASA

Experts say it could take a decade or so before electric planes are ready for widespread commercial passenger use. But some airlines, like United Airlines, are pushing to electrify aircraft as early as 2026. So, while we cannot expect electric aircraft to be a major component of sustainable aviation any time soon, they should be able to play at least a minor role in the coming years.

The Future of Sustainable Aviation Fuel

Clearly, we have begun the transition towards sustainability for the aviation industry. The industry seems to be strongly behind it – and regulation is also driving the transition.

There appear to be some questions about the approach being taken to create the current definition for SAF, but understanding what those questions are should enable SAF producers to avoid the results being warned about – or at least dramatically reduce them.

As described here, there are some alternatives to what is currently considered SAF – most notably hydrogen and battery-operated aircraft and potential methanol – which should make aviation even more sustainable. These should probably simply be considered as part of - rather than alternatives to - SAF. Aviation companies – and the companies building SAF fuels – should be aware of all of the possible options – and all of the possible issues – and move forward to transition the aviation industry as quickly and effectively as possible.