European SAF Industrial Policy

Ensuring the competitiveness of European aviation, energy, and connectivity

January 2025

ICF

1 Executive Summary

It is a pivotal time for the sustainable aviation fuel (SAF) market. Following decades of development, SAF production is gaining momentum, with production volumes forecast to reach 16 Mt in 2030 – a considerable increase from the 1 Mt produced in 2024[1]. As SAF evolves into a global industry, it will redistribute energy production, create thousands of skilled jobs, and significantly reduce emissions from the aviation industry.

This growth reflects a meaningful commercial opportunity, with the value of the global SAF market forecast at nearly €15 billion by 2030. Decarbonising aviation will require the SAF industry to attract cumulative investment of up to €3.7 trillion by 2050,[2,3,4] overcoming challenges across technology, market risks, and feedstock access.

The EU has built a sophisticated policy framework to support SAF demand. The ReFuelEU Aviation Regulation mandates fuel suppliers to blend increasing volumes of SAF into the EU's jet fuel supply, with a sub-mandate for synthetic SAF produced from low-carbon electricity. The ETS increases the cost for fossil fuel emissions, complemented by measures under the Renewable Energy Directive, Taxonomy, European Taxation Directive, and other initiatives.

However, more must be done for the EU to maintain industry leadership and achieve climate targets.

The industrial strategies implemented in China and the US have accelerated investment in SAF in both countries. The combination of supportive policies, such as the Inflation Reduction Act in the US, and cheap energy, loans, and other mechanisms in China have created an unequal competitive landscape. This is further tilted against EU producers through disadvantages in several fundamental factors, including those highlighted in Mr Draghi's report on *The future of European competitiveness*,[5] such as electricity prices, construction costs, permitting times, and access to feedstocks.

In the absence of additional measures, EU refineries will face intense competition and growing quantities of SAF are likely to be imported to meet the ReFuelEU Aviation mandate. European customers will shoulder the cost burden, but an increasing share of jobs will be created in other countries, and the EU will remain dependent on foreign providers for energy.

The SAF industry also faces a more fundamental challenge with the developments and investments in advanced SAF technologies lagging the pace needed. This is pronounced for technologies that utilise feedstocks from the more sustainable and scalable feedstocks listed in Annex IV Part A and synthetic SAF from low-carbon electricity. The combined price uncertainty, technology risks, and policy risks have held back investments, risking that obligated parties will fail to meet the mandate. In this worst-case outcome, costs are driven up for

[1] https://www.iata.org/en/iata-repository/pressroom/fact-sheets/fact-sheet-sustainable-aviation-fuels/
[2] https://aviationbenefits.org/environmental-efficiency/climate-action/waypoint-2050/
[3] https://www.iata.org/contentassets/8d19e716636a47c184e7221c77563c93/finance-net-zero-roadmap.pdf
[4] Using the 12-month average USD to EUR exchange rate of 0.925
[5] https://commission.europa.eu/topics/strengthening-european-competitiveness/eu-competitiveness-looking-ahead_en#paragraph_47059

consumers with no environmental benefit. The EU should implement additional measures to break this standoff, unlock private investments and ensure advanced SAF technologies can scale to meet the required volumes, while maintaining aviation connectivity at an appropriate price.

The Clean Industrial Deal and Sustainable Transport Investment Plan must address these challenges, by ensuring a level playing field for European producers and encouraging investment into the technologies needed for the industry to scale. This should not require excessive taxpayer financing to achieve. Improved public-private risk sharing is crucial to reduce the risk for first-of-a-kind facilities, and experience in the UK Offshore Wind Contract-for-Difference scheme shows that many project developers will trade risk for a lower price – reducing costs for customers, taxpayers, and accelerating deployment[6]. Adjustments to existing policies could also reduce costs and increase benefits.

The following set of measures presents a policy toolbox for the EU to catalyse SAF production and address the challenges facing the domestic EU SAF industry:

Mobilizing capital for competitive SAF production in Europe

1. **Reducing market risk.** Risk-sharing mechanisms would unlock private investments while reducing costs for consumers. Contracts for Difference have proven effective for the wind sector, and carbon contracts for difference are increasingly implemented within the EU to support green hydrogen, carbon capture, and other emerging technologies.[7,8] An EU-wide scheme could enhance fairness between member states and ensure the technologies and skills for low carbon aviation are developed in Europe.

2. **Focused investment support for advanced SAF facilities.** Initial commercial facilities are capital-intensive, requiring financial support to catalyse construction. Capital grants or loan guarantees can encourage private capital, and could be provided through adjustments to existing schemes; for example, by adjusting criteria in the EU ETS Innovation Fund to recognise the unique nature of SAF projects. Sector-specific allocations in the ETS Innovation Fund would ensure like-for-like comparisons, and simplifying the application process, consultation, and integration with schemes such as the Hydrogen Bank would all improve the effectiveness. Other countries have used similar programs to effectively support SAF, including in the US (€239 million awarded under FAA FAST SAF[9]), UK (€178 million awarded under GFGS and AFF[10]), Australia (€14 million awarded under ARENA[11]) and Japan (budget of €1 billion under Green Innovation Fund[12]).

3. **Ensuring feedstock access.** Policies should account for the limited alternatives to decarbonise hard-to-abate sectors such as aviation, ensuring the available feedstocks are efficiently allocated. The electricity required to meet the synthetic SAF sub-mandate must be accounted within the EU's energy supply plans, and mechanisms should ensure producers can access electricity at globally competitive prices. Biogenic wastes and residues should be prioritised for sectors with few alternatives, for example by adjusting the

[6] https://uk.news.yahoo.com/fact-check-many-wind-power-153353158.html
[7] https://ec.europa.eu/commission/presscorner/detail/en/ip_23_128
[8] https://www.klimaschutzvertraege.info/en/home
[9] https://www.faa.gov/general/fueling-aviations-sustainable-transition-fast-grants
[10] https://www.gov.uk/government/publications/advanced-fuels-fund-competition-winners/advanced-fuels-fund-aff-competition-winners
[11] https://arena.gov.au/news/sustainable-aviation-fuels-studies-take-flight/#:~:text=The%20two%20projects%20include%3A,at%20the%20company's%20Lytton%20refinery.
[12] https://green-innovation.nedo.go.jp/en/project/development-fuel-manufacturing-technology-co2/scheme/

waste hierarchy to prioritise the use of biogenic wastes for SAF production over incineration (with energy recovery). The eligibility of re-used fossil CO2 feedstocks could be extended beyond 2041 for producers that commission in advance, ensuring sufficient time to achieve the payback period.

Measures to increase the efficiency of existing mechanisms

4. **Ensure an efficient market through a book and claim mechanism.** The ReFuelEU Aviation obligation currently requires both physical SAF and environmental attributes (including ReFuelEU Aviation compliance tickets) to be mass-balance allocated to Union airports. While this allocation has some benefits, a system which allows obligated parties to trade some portion of the compliance tickets independently from the physical fuel (e.g., through a book and claim mechanism), could facilitate market efficiency and price reductions. Such a system would encourage the construction of SAF facilities in regions where production is most cost-effective, and reduce the market power of the incumbent companies that control the fossil fuel value chain. This would need to be carefully coordinated with the ETS claims and scope 3 allocations.

5. **Improving the ETS re-investment allocation.** The FEETS allocation of 20 million SAF allowances[13] provides welcome support to the sector, although the uncertainty, allocation, and volume of allowances limits the effectiveness. An auction for multi-year allocations in parallel to industry offtakes would provide certainty to airlines and producers, and would facilitate bankable agreements. Visibility on future increases to the volume, or feed-in mechanisms from allowances surrendered by aviation would provide further clarity.

6. **Refining the ReFuelEU Aviation Mandate.** The mandate includes 5-year steps, each with abrupt increases. SAF is supplied through large infrastructure projects, which are slow to build and align to this profile. Smoothing the increases would limit the under/over-supply of SAF and the resulting market volatility.

7. **Commercialising advanced SAF (Annex IX Part A).** HEFA SAF, using UCO and waste tallows from Annex IX Part B of Directive (EU) 2018/2001 on the promotion of the use of energy from renewable sources (RED II), provides an effective foundation for the SAF industry. However, technologies to commercialise advanced feedstocks in Part A of Annex IX have not been able to compete due to higher production costs and risk profiles. Existing measures must be amplified to make advanced SAF investable, by providing revenue certainty (recommendation 1), providing targeted support (recommendation 2), allowing bankable offtake through improvements to the ETS allowance scheme (recommendation 5), and increasing their multiplied contributions under the RED (currently 1.2x energy content, compared to 1.0x for Part B[14]). This support is crucial to reduce dependence on constrained feedstocks and diversify the production opportunities.

[13] https://climate.ec.europa.eu/document/download/9a82627a-8a5c-4419-93de-e5ed2d6248eb_en?filename=policy_ets_allowances_for_saf_en.pdf&prefLang=hu
[14] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A02018L2001-20240716&qid=1722839014742#tocId4:~:text=the%20share%20of%20advanced,times%20their%20energy%20content%3B

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2 Introduction

Report Purpose

The SAF market is accelerating, but current projections fall short of ambitions. Industrial strategies in other countries have created an unequal competitive market, challenging EU SAF production. The Clean Industrial Deal and Sustainable Transport Investment Plan have an opportunity to address these challenges, attracting investment to the EU, improving energy security, and ensuring climate targets are met.

This report describes the context, identifies the key challenges, and recommends measures to create a successful SAF industry in the EU.

Sustainable Aviation Fuels (SAF) are drop-in alternative jet fuels produced from non-fossil or waste resources that meet the stringent technical specifications of ASTM D7566. By using carbon from renewable or waste sources rather than fossil sources, SAF achieves emissions reductions compared to conventional jet fuel, making it a cornerstone of aviation's decarbonization strategy. SAF is blended with conventional jet fuel (ASTM D1655) up to 50% by volume, depending on the SAF production technology pathway. Once blended, the fuel is reclassified as an ASTM D1655 aviation fuel. From the user's perspective, the resulting fuel is indistinguishable from traditional conventional jet fuel (e.g., Jet-A), requiring no modifications to aircraft or fuelling infrastructure.

SAF is compatible with existing airport and aircraft infrastructure, and has been used at over 125 airports worldwide, powering more than 500,000 commercial flights across over 50 airlines.[15,16] Production is accelerating, with global output rising from 0.3 Mt in 2022 to 0.5 Mt in 2023, and to 1 Mt in 2024, comprising 0.3% of global jet fuel production.[17] The EU has led the industry with a framework of policies, alongside the US, UK and other countries at earlier stages of development.

However, more must be done. Current volumes represent less than 1% of global jet fuel consumption, and as much as 400 million tonnes per year could be required for the aviation industry to meet net-zero targets by 2050.[18] Achieving this will necessitate a fundamental transition in the energy sector, including the development of new technologies, infrastructure and substantial investments. Despite considerable efforts, all three of these requirements are lagging their required trajectory.

Globally, biofuels contributed around 4.3% of on-road energy consumption in 2022,[19] consuming 17% of global vegetable oil production and as much as a fifth the total production of some crops[20] – particularly corn and soybeans in the US, sugarcane in Brazil, and palm oil in Indonesia. Valuable lessons have been learned from the development of these feedstocks, but they cannot be scaled to meet all demands of net-zero transport.

[15] https://centreforaviation.com/analysis/reports/airlines-closing-in-on-saf-flights-milestone-but-progress-remains-incremental-653315
[16] https://www.i6.io/blog/which-airlines-are-embracing-saf
[17] https://www.iata.org/en/pressroom/2024-releases/2024-12-10-03/
[18] https://www.iata.org/contentassets/8d19e716636a47c184e7221c77563c93/energy-and-new-fuels-infrastructure-net-zero-roadmap.pdf
[19] https://www.ifpenergiesnouvelles.com/article/biofuels-dashboard-2023#1
[20] https://www.iea.org/reports/is-the-biofuel-industry-approaching-a-feedstock-crunch

Competitive production costs and lower technology risks have maintained a focus on crop-based production in other sectors. Only EU aviation has been restricted from using any food crop-based feedstocks, as SAF produced from these feedstocks is not eligible for compliance with the ReFuelEU Aviation mandate. This places an additional burden on aviation compared to other sectors, which stand to benefit from the spillover effects of the development of technologies that use non-crop feedstocks.

The waste-based alternatives are diverse, and offer a variety of sustainability, scalability, and risk characteristics. By far, the most successful alternative has been the use of Used Cooking Oil (UCO) and waste animal fats to produce SAF through the HEFA pathway. This has multiple advantages, with a high energy density feedstock that allows large-scale, centralised production, an excellent carbon intensity profile and a comparatively low-risk technology. However, the success of HEFA also creates challenges. UCO demand has exceeded the availability in the EU, driving an increasing reliance on imports and simultaneously increasing the comparative advantage for producers outside the EU to move up the value chain and export fuels rather than feedstocks. HEFA has also effectively out-competed alternative technologies. A financier considering an investment in an alternative facility, for example using cellulosic wastes for SAF production, would see benefits that accrue to the industry through the development of needed technologies, but would be unlikely to achieve a profitable investment for their own shareholders due to the higher technology risk, higher production price, but similar revenue profile compared to HEFA[21]. This misalignment of benefits has resulted in scarce EU investments in technologies beyond HEFA.

Synthetic SAF (eSAF) production faces similarly strong headwinds. Production of SAF from renewable electricity promises a scalable and sustainable alternative, although with high costs at the early stages of development. The EU sub-mandate creates a clear market with many green shoots of momentum, and a multitude of producers have been announced across the EU. However, few have succeeded in raising the required capital due to risks from imports, policy dilution, and technologies. Electricity is the main cost driver for synthetic SAF production, and some other countries achieve significantly lower costs for electricity; for example, the IEA estimated that wholesale electricity prices in the US and China were half that in the EU in 2023.[22] This creates a significant risk that overseas producers may be able to undercut domestic production, although the complete dependency on EU policy may also make foreign investors hesitant, leading to a stand-off that leads to global scarcity. The pivotal role of a single policy makes dilution a risk, as any adjustments to the EU sub-mandate (volume, eligibility criteria, or similar), however unlikely, may make initial producers uncompetitive. The technology risk adds compounding challenges, leading to the lack of capital flowing into the market.

These are crucial issues for the EU to address. Without further measures, the decarbonisation of EU aviation will increasingly rely on uncertain access to feedstock and fuels from overseas producers, and the technologies for more scalable and sustainable production are unlikely to be commercialised. The spectre of policy failure is a very real threat if the Clean Industrial Deal does not support the SAF market through these early stages of development.

[21] The RED multiplier and EU ETS-Financed support are recognised and discussed later.
[22] https://www.iea.org/reports/electricity-2024/executive-summary

The benefits from addressing the challenges are clear. Investments in SAF production and supply chains create jobs, foster innovation, and drive economic growth. The opportunity is robustly aligned to the ethos of the Clean Industrial Deal Mandate, simultaneously facilitating EU industrialisation and decarbonisation and allowing Europe to develop technologies, skills, and a workforce fit for future industries.

This document evaluates the requirement and opportunity in detail. It is organised into three sections: first considering the key trends in the SAF market, then considering the resources and policies that drive the market, and finally identifying potential solutions for the EU to address the challenges.

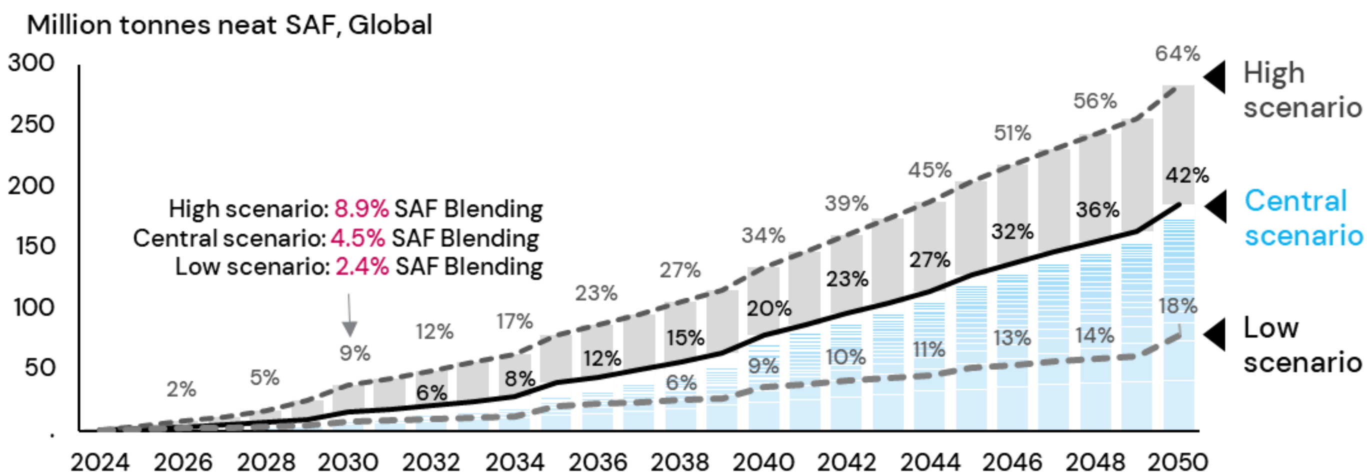
3 SAF Market dynamics and the implication for Europe

3.1 SAF Market overview

Policy is crucial to scale SAF production. Competition and thin margins in the aviation industry mean airlines alone cannot absorb the cost premium for SAF on a voluntary basis. Airports, corporate travellers, and others in the value chain must also play important roles, but government policy will remain the cornerstone. Recognising this, governments worldwide are enacting policies to stimulate SAF production and adoption.

By analysing global SAF policies, ICF forecast policy-driven SAF demand. Recognising the uncertainty arising from the non-binding nature of SAF targets in many regions - where actual outcomes may fall short of or exceed stated goals - and the variability in potential mandates within emerging regions, ICF developed a central and high scenario. These scenarios forecast policy-driven SAF demand in 2030 ranging from 8.1 Mt to 30.6 Mt, with 15.2 Mt in the central scenario.

ICF forecasts between 8.1 and 30.6 Mt of global SAF demand from governmental policies by 2030, equating to a global 2.4 – 8.9% SAF blend

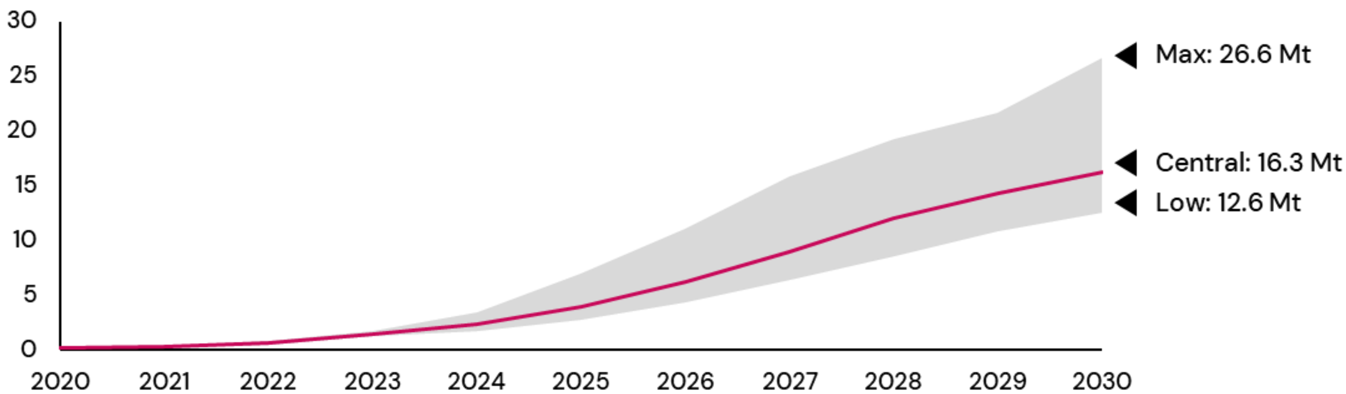


Source: ICF analysis of public announcements. The Central scenario assumes the 47 countries actively developing policies implement these at a reasonable level, including the EU, UK, US, Canada, Brazil, Australia, Japan, Malaysia, Indonesia, Singapore, India, China, and others. The Low scenario only includes countries with policies in-place, such as the EU, UK, US, and Singapore. The High scenario assumes global targets, such as CAAF/3 are met through initiates in additional countries. ICF notes that this is a forecast based on present-day assumptions, and higher volumes may be achieved if aspirations and resulting policies accelerate over the coming years.

These policies have attracted considerable investment into production facilities. Globally, over 250 SAF facilities are operational or have been announced, encompassing a range of feedstock-technology pathways and countries. ICF analysis, accounting for factors such as feedstock risk, technology risk, and project developer maturity, forecasts SAF production to reach 16.3 Mt in the central scenario by 2030, representing a 25-fold increase from 2023 levels. ICF also calculates the maximum scenario, which assumes all announced facilities commission on-time and at their announced production levels. This suggests production potential of 26.6 Mt by 2030, setting an upper bound on supply and illustrating the strong momentum in the industry.

ICF forecasts between 12.6 and 26.6 Mt of neat SAF to be produced globally by 2030

Million tonnes neat SAF, Global



Notes: ICF Analysis of public announcements, adjusting for a failure and slippage rate resulting from technology, commercial, and other risks.

This analysis shows the rapid acceleration across the SAF industry, with policy-driven demand increasing to 15.2 Mt by 2030, and supply estimated at 16.3 Mt by the same year. Voluntary commitments from airlines and corporate buyers are important levers to further increase demand. Over 52 billion litres (c. 42 Mt) of SAF offtake agreements have been signed by airlines and fuel companies to date[23], and ICF estimates that Corporate SAF purchases of the Scope 3 emissions attributes reached values of up to $100m in 2024.

Despite this success, the SAF market faces several challenges. Over two thirds of announced supply use UCO and waste tallows, which provide an important foundation for the industry, but are supply constrained. Additional technologies must be developed to enable the use of more scalable and sustainable feedstocks and ensure the industry can continue scaling as UCOs and tallows become increasingly difficult to access. Policy is crucial to ensure these additional technologies can develop through the risky early stages.

Other challenges are specific to EU production. Pioneering EU policy has stimulated production in Europe, but as the SAF industry has become increasingly global, EU producers risk rapidly eroded market share from imports that use a lower cost base and (in some locations) access supportive policies. Current EU policy, such as the ReFuelEU Aviation Mandate and ETS, is focused on demand-side policies, but without supply-side support to ensure level competition, the economic benefits, jobs, and industrial drivers will flow to other countries.

ICF have identified 6 key trends in the current SAF market, and each is described further in the following section.

[23] ICAO SAF Offtake Agreements

Section summary: SAF market dynamics

- ICF forecasts a policy-driven demand ranging from 8.1 Mt to 30.6 Mt, with 15.2 Mt in the central scenario by 2030, equating to between 2.4 and 8.9% of global jet fuel uplift in that year.
- Taking into consideration factors such as feedstock risk, technology risk, and project developer maturity, forecast SAF production reaches 16.3 Mt in the central scenario by 2030.
- While this shows the strong momentum in the SAF market, several areas of weakness exist – particularly with the forecast decrease in EU production market share, and the lack of progress made developing the advanced and synthetic SAF technologies required to achieve the ReFuelEU Aviation Mandate.

3.2 Six key trends in the global SAF market

The dynamism and complexity of the SAF market make precise forecasting challenging; however, beneath the headline figures, ICF identify the following 6 trends:

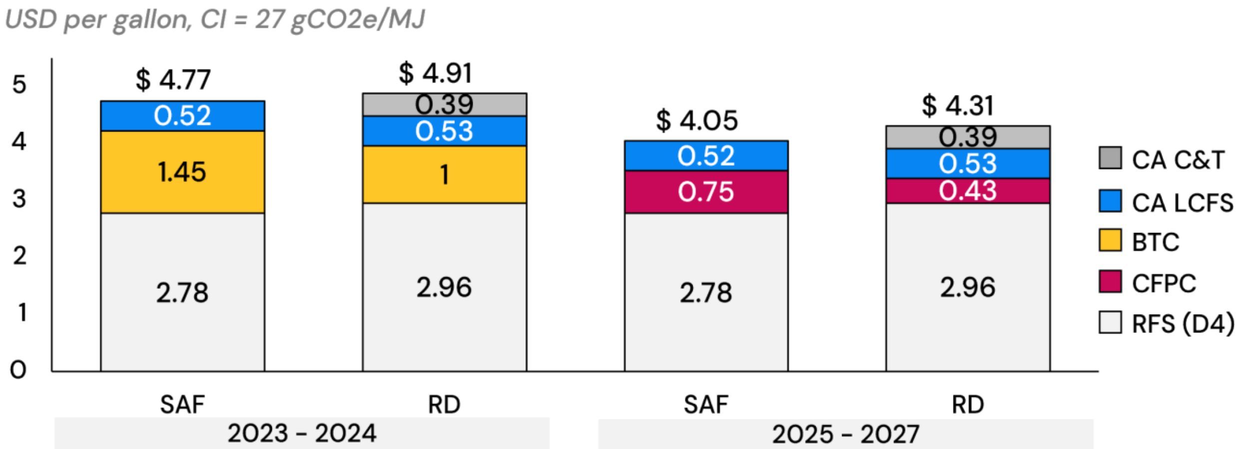
1. **Potential imports from the US if the EU market price increases:** The US policy framework includes multiple supportive federal policies. The SAF Blenders Tax Credit (BTC) is currently offered through the Inflation Reduction Act for eligible SAF sold or used between December 31st 2022 and January 1st 2025. This benefit applies to blenders of eligible SAF, typically fuel suppliers, meaning imported SAF is eligible under the scheme. $1.25 in credit is offered for each gallon of SAF in a qualifying blend with a greenhouse gas emissions saving of at least 50%, with a further $0.01 offered for each additional percentage point reduction, up to a maximum credit of $1.75 per gallon.

   From the start of 2025, the BTC will be replaced with the Clean Fuel Production Credit (CFPC), shifting support from blenders to producers and removing the eligibility of imported SAF.[24] The CFPC is an incentive for US producers, and is likely to have a near-term impact by diverting current SAF imports to the US to other countries, and may make US production more competitive if the US starts to export SAF.

   The HEFA production process is basically the same for both SAF and renewable diesel (RD), with producers able to adjust yields to prioritise one over the other. This creates direct competition between the two products. RD also benefits from federal and state incentives in the US and receives a higher monetary value than SAF per gallon. Additionally, SAF production is typically more expensive than RD due to the greater hydrocracking required and the generation of less valuable co-products. As a result, very little SAF is currently produced in the US, as RD tends to be more profitable. As an example, in US in 2023, close to 3 billion gallons of RD was produced, compared to just 24 million gallons of SAF[25,26].

[24] https://afdc.energy.gov/laws/13321
[25] https://afdc.energy.gov/fuels/sustainable-aviation-fuel
[26] https://biomassmagazine.com/articles/usda-growth-in-us-renewable-diesel-production-impacts-global-feedstock-trade

The US value stack is tilted towards RD, and will require SAF to rise over c. $2,200 per tonne before export is more profitable



Source: https://www.nrel.gov/docs/fy24osti/87802.pdf. This analysis assumes that the SAF and RD are sold in California as this represent the highest market value. Monetary values calculated based on 2024 prices. "CA C&T" represents California cap and trade.

This large size of the US RD industry means that any changes to this dynamic could result in large volumes of SAF quickly entering the market. ICF anticipate this occurring under three potential scenarios: (1) If changes to policies level competition between SAF and RD, (2) if the RD markets become saturated (for example, ICF notes that over half of diesel consumed in California was renewable in 2024), and (3) if SAF prices in the EU increase to make it more profitable to export SAF to the EU rather than blend RD in the US.

At 2024 prices, SAF would need to cost at least $2,200 per tonne for exports to become more profitable. This dynamic is important to protect the aviation industry from price rises, although it reduces the upside for producers and therefore disincentivises investors. It also increases the risk for EU production that may struggle to compete with US imports that can access generous production incentives.

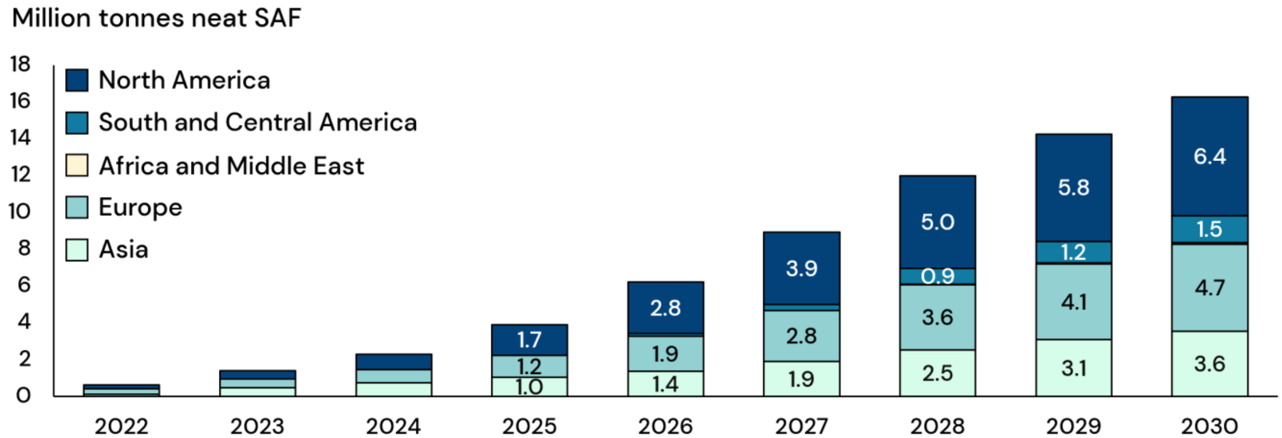
2. **Increasing competition from Asia:** Asia has traditionally been an exporter of feedstock with China currently exporting significant quantities of UCO into the US and Europe.[27] However, recognising the economic and energy security benefits of developing a domestic SAF industry, China and its neighbours in the region are aiming to move up the value chain.

   Several Chinese SAF facilities are already operational in 2024, with shorter lead times for SAF capacity coming online in China compared to other regions.[28] SAF production at Neste's facility in Singapore started in April 2023, with a capacity of 1 Mt of SAF per year.[29] EcoCeres operates a SAF facility north of Shanghai,

[27] https://www.reuters.com/markets/commodities/bidens-ira-drives-surge-us-imports-chinese-used-cooking-oil-2023-09-22/
[28] https://skynrg.com/wp-content/uploads/2024/06/SAF-Market-Outlook-2024-Summary.pdf,
[29] Singapore home to world's largest production facility for jet fuel made from waste materials | Singapore EDB

producing 0.35 Mt renewable diesel and SAF per year, and is constructing a new facility in Malaysia to produce up to 0.4 Mt of SAF, RD and renewable naphtha annually.[30] South Korean company LG Chem and Italian firm Eni recently set out a joint venture to develop a facility in South Korea which will have a 0.4 Mt capacity across multiple products, including SAF, RD, and bio-naphtha.[31] In 2023, BP invested ~$50 million in a partnership with a Chinese biofuel company to support the development of a new 0.5 Mt SAF facility in Eastern China.[32]While announced capacity in Asia is relatively limited (ICF estimate 3.6 Mt by 2030), recent announcements suggest that supply may rapidly increase over the coming years.

Most announced capacity is in the EU and North America, but recent announcements emphasise the growing role of Asia



ICF Analysis

Demand for SAF in Asia is increasing, although the policies are at earlier stages of development compared to the EU. Singapore has enacted policy for 3-5% SAF by 2030, (0.15+ Mt), with the percentage calibrated to the market developments. China have announced targets to produce 10 Mt SAF by 2030. Japan, China, Australia, Indonesia, and Malaysia have all announced policies under development. Due to their considerable jet fuel consumption, these policies could significantly increase demand, although exact details are still to be confirmed.

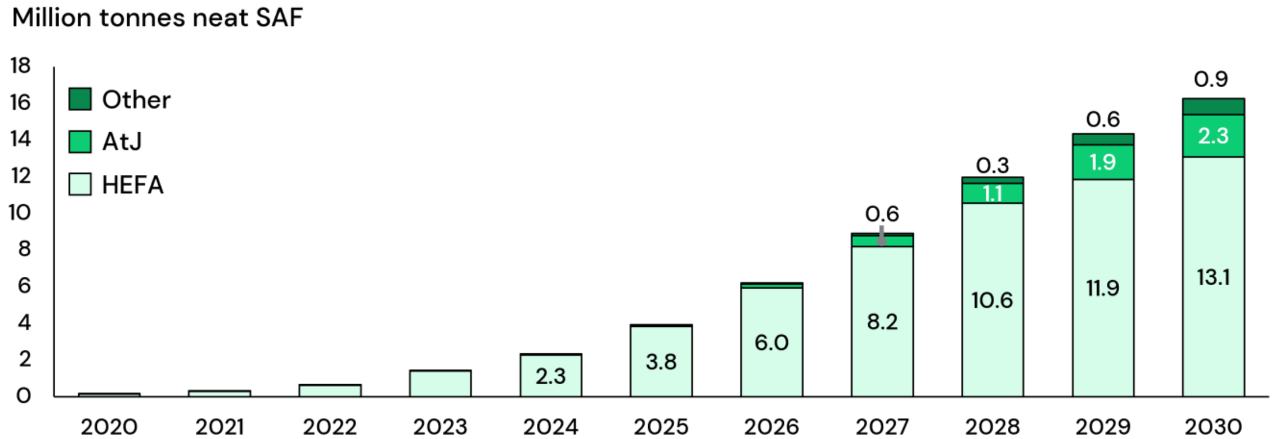
The continued rise of Asia could benefit the EU by providing a large supply of imported SAF. However, this simultaneously creates the risk of further de-industrialisation and scarcity if demand increases across Asia and the feedstocks are more difficult to access.

3. **Dominance of HEFA**: Given its relative technological maturity and commercial readiness, HEFA (including co-processing) accounted for over 99% of SAF produced globally in 2023. ICF analysis projects that over

[30] https://www.greenairnews.com/?p=5985
[31] https://www.safinvestor.com/news/144164/lg-chem-eni-to-setup-biorefinery-in-south-korea/
[32] https://www.reuters.com/business/energy/chinas-zhejiang-jiaao-signs-sustainable-aviation-fuel-deal-with-bp-2024-08-23/

80% of SAF produced in 2030 will be produced through the HEFA pathway. This figure is likely to be an underestimation as a trend of co-processing (where HEFA feedstocks are processed alongside conventional crude oil in existing refineries) and retrofit approaches (where existing facilities are retrofitted to process HEFA feedstocks in place of crude oil feedstocks) emerge. These processes hold promise as they represent the shortest-cycle sources of supply, with lower capital costs than purpose-built facilities. For co-processing in a refinery with less than 5% volume typically requires only a change of catalyst in the unit and small operational adjustments. The UK is a notable exception to the trend of HEFA dominance in 2030 announced capacity, largely due to the HEFA Cap within the UK SAF mandate which sets a limit of 71% of SAF permitted to be HEFA SAF by 2030 and 35% by 2040.

HEFA is expected to dominate SAF production until 2030, followed by a shift to advanced SAF production pathways



ICF Analysis

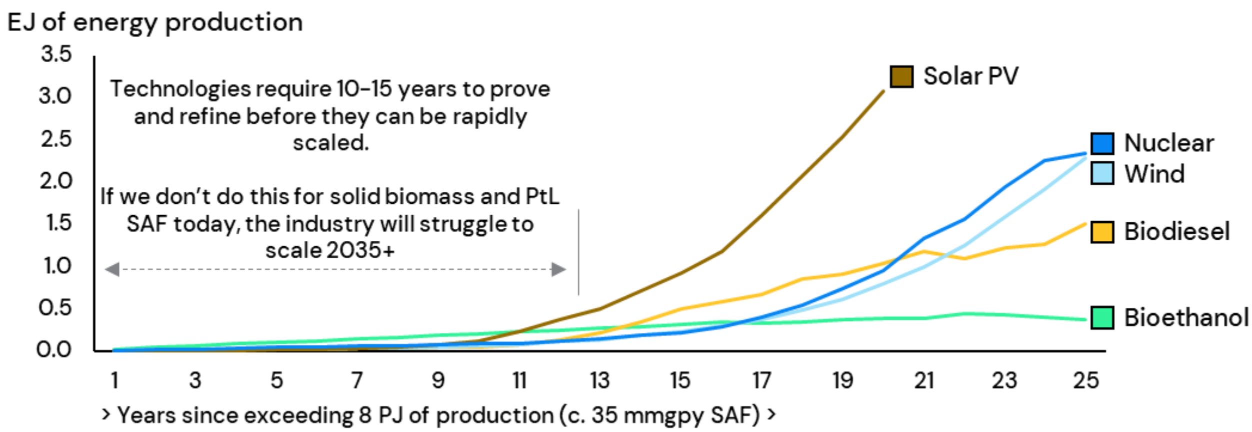
HEFA SAF production benefits from the technological maturity of the RD industry, which developed the process and feedstock supply chains that are now leveraged for SAF. However, the RD and SAF industries are increasingly competing for feedstocks. The US, for example, is already a net importer of waste oil feedstock due to demand from both its SAF and RD industries. ICF expects that by 2030 HEFA SAF volumes will plateau as feedstock becomes constrained.

HEFA feedstock constraints also relate to regional restrictions on the types of feedstocks that are eligible under various schemes. In principle, HEFA SAF can be produced using a variety of oils and fats – including food crop-based oils like soybean oil and canola oil, which are used extensively in the US for both RD and SAF production. However, with the ineligibility of SAF derived from food crop-based feedstocks in the EU for ReFuelEU Aviation, UCO has emerged as the predominant feedstock, of which there is limited availability and a reliance on imports. The EU has recently expanded its allowable pool of feedstocks to include feedstock from degraded land and intermediate crops – cover crops which improve soil stability during the "downtime" between food crop rotations and therefore do not cause additional pressure on food production. But the quantity of such feedstock that can be produced sustainably and economically is still unknown.

While HEFA SAF will be the primary contributor to meeting ReFue lEU targets, its role will plateau post-2030 when feedstocks are expected to become increasingly constrained.

4. **Headwinds for advanced technologies:** While HEFA and co-processing are scaling rapidly, other technologies have faced stronger headwinds. Advanced technologies can broadly be considered in three categories: (1) Alcohol-to-jet (AtJ), (2) emerging technologies such as Fischer-Tropsch (FT), and (3) Synthetic SAF production from renewable electricity. As shown in the following diagram, case-study novel technologies require 10+ years from pre-commercial production before they can rapidly scale. The rapid increases under the EU's ReFuelEU Aviation mandate will require that Advanced SAF technologies (Using feedstocks from RED IX Annex A) are developed today in order to scale in after 2030.

Achieving the mid-term targets for SAF in the EU will depend on efforts to develop advanced technologies today



Source: ICF Analysis of the 2023 Statistical review of world energy

The AtJ pathway is gaining momentum, particularly in the US, where it can leverage the well-established bioethanol industry. The US produces over 15 billion gallons of ethanol annually, with significant volumes exported. This oversupply, combined with the expected dampening effect of electric vehicle adoption on gasoline demand, has increased the quantity of ethanol potentially available to aviation. Ethanol offers advantages as a stable and easily transportable intermediate chemical in biomass conversion, benefiting from mature production pathways and a diverse range of feedstocks. Companies such as LanzaJet and Gevo have announced ambitious AtJ projects, with LanzaJet's 10 million gallon per year (0.03 Mt) Freedom Pines facility entering operation this year. A successful commercial scale AtJ facility will reduce project risk for subsequent projects.

However, the use of food crop-derived ethanol production is prohibited for SAF mandated by ReFuelEU Aviation or the UK's SAF mandate. While the feedstock limitations will mean AtJ in the EU will lag the US, as the AtJ technology is matured, pathways to use ethanol for SAF will be de-risked, creating an opportunity for the EU to be a fast follower by focusing on cellulosic ethanol technologies.

Fischer-Tropsch (FT) technology is an alternative production pathway for SAF which has the potential to use municipal solid waste (MSW) as feedstock. MSW is a readily available waste resource, the use of which has the co-benefit of addressing waste management, a key focal point in EU. However, MSW is a highly nonhomogeneous feedstock – every tonne of MSW will have a different composition. MSW is also highly acidic, toxic and corrosive. These factors combined present technological challenges for refining MSW into SAF on a commercial scale – as demonstrated by the challenges faced by Fulcrum's *Sierra* MSW project. Additionally, FT facilities typically are considerably CAPEX-intensive, making it challenging to obtain financing and increasing the payback period once the plant becomes operational.

Due to HEFA feedstock limitations and limited eligible imports, ensuring advanced SAF technologies reach commercial scale is essential to the EU. This will also diversify the industry to ensure future success is not singularly development on the development of synthetic SAF.

5. **Uncertain business case for synthetic SAF:** Synthetic SAF encompasses a range of pathways that use captured CO_2 and non-fossil-derived hydrogen to make SAF. The hydrogen is produced by electrolysis powered by either renewable electricity or low-carbon non-fossil electricity (e.g. nuclear). The hydrogen and captured carbon is used to produce, either syngas or methanol, which are then upgraded to produce SAF. These set of pathways hold promise due to their scalability and the significant emission reduction possible. However, these pathways require abundant quantities of green hydrogen, and rely upon carbon capture processes, which are expensive and SAF producers will face competitive for access.

   Less than 1% of global hydrogen produced is low-carbon hydrogen, which is required for synthetic SAF[33]. Additionally, although significant progress is being made in Europe in both Carbon Capture, Usage and Storage (CCUS) from industrial facilities and in Direct Air Capture technology[34], the scale of commercial deployment has been limited and remains expensive. Even if captured CO_2 is available, converting it into carbon monoxide - a necessary step in the PtL via FT pathway, the most widely used pathway in announced facilities - requires significant energy input due to the highly endothermic nature of the process.

   Access to large quantities of low-cost renewable electricity is a fundamental constraint for PtL pathways. The Delegated Act[35] stipulates that this electricity, to be considered renewable, must meet several additionality criteria, ensuring it is derived from new capacity rather than diverting existing renewable resources, to ensure true sustainability and alignment with climate goals.

   The EU synthetic SAF sub-mandate creates a market for fuel produced through this process, and a multitude of producers have been announced across the EU. However, few have succeeded in raising the required capital due to risks from imports, policy dilution, and technologies. Electricity is the main cost driver for synthetic SAF production, and some other countries achieve significantly lower costs for electricity; for example, the IEA estimated that wholesale electricity prices in the US and China were half that in the EU in 2023[36]. This creates a significant risk that overseas producers may be able to undercut domestic

[33] https://www.iea.org/energy-system/low-emission-fuels/hydrogen
[34] See e.g. the Acorn Project (based in Scotland) and Climeworks (based in Switzerland).
[35] Commission Delegated Regulation (EU) 2023/1184
[36] https://www.iea.org/reports/electricity-2024/executive-summary

production, although the complete dependency on EU policy may also make foreign investors hesitant, leading to a stand-off that leads to global scarcity. The pivotal role of a single policy makes dilution a risk, as any adjustments to the EU sub-mandate (volume, eligibility criteria, or similar), however unlikely, may make initial producers uncompetitive. The technology risk adds compounding challenges, leading to the lack of capital flowing into the market. Addressing these risks will be crucial to ensure the supply of synthetic SAF is developed to meet demand.

6. **Market volatility:** The global SAF market is characterised by large infrastructure investments on the supply side, and a patchwork of national, regional, and global policies that mandate, incentivise, and enable the market. There is a mismatch in the responsiveness of supply and demand, with policy changes able to drive rapid and large swings in demand, while production facilities require many years to build and commission. As the market shifts to technologies such as AtJ, FT, and synthetic SAFs, the responsiveness of supply may further reduce as these technologies have high capital costs that require consistent operation to pay back debts. Alongside the constraints on co-processing (through feedstock and blending limits), this limits the capacity for suppliers to adjust production to match short-term shifts in demand.

   The potential volatility is accentuated by policy choices. The ReFuelEU Aviation Mandate require large increases in production in steps, which supply is unlikely to be able to exactly replicate. Policies in many other countries, such as the tax credits in the US, often have expiration dates that may substantially alter market economics depending on their expiry or renewal. This volatility hinders investments, with the lack of clarity on pricing increasing the risk-adjusted return required for capital.

Section summary: SAF Market Key Trends

- The US offers the highest value stack for SAF and has rapidly grown their renewable fuel industry. However, policies currently favour renewable diesel over SAF. High EU SAF prices could attract significant imports of US-produced SAF.
- Asia is a key HEFA feedstock supplier and is increasingly moving up the value chain to become a producer. This will create intense competition for EU-based producers and leaves the EU increasingly dependent on other countries.
- HEFA, benefiting from the technological maturity of the RD industry, accounted for 99% of SAF in 2023 and is forecast to produce approximately 80% of SAF by 2030.
- Advanced SAF technologies are essential for the EU but are developing more slowly than required. This must be accelerated to ensure the industry is not overly dependent on just the HEFA and Synthetic SAF pathways.
- Synthetic SAF is struggling to attract investment due to high costs of green hydrogen, carbon capture, and renewable electricity. While the EU sub-mandate creates market demand, capital remains scarce due to technology risks, policy uncertainties, and potential competition from lower-cost overseas producers.
- SAF market volatility, driven by policy-driven demand swings and slow, capital-intensive supply responses, creates investment uncertainty and hinders market growth. This should be a key target for policy to address.

4 SAF market fundamental drivers

This section evaluates how the global market is shaped by underlying fundamentals and policies. This provides crucial context for the necessity and nature of the EU's Clean Industrial Deal and is aligned to the findings of Mr. Draghi's report on The Future of European Competitiveness.[37]

4.1 SAF fundamental drivers

Energy is the most widely traded global commodity. Thousands of ships, millions of km pipelines, and fleets of tankers move crude and refined hydrocarbons from supply hubs to the highest value markets. This is increasingly reflected in the global SAF market. The maturity of existing energy logistics provides a powerful tailwind for this trend, allowing the lowest cost production to be connected with the highest value markets for little cost and carbon penalty. The reduced importance of proximity creates many opportunities for the EU to use imports to meet climate goals for less cost, but this simultaneously increases the competition for local production and the associated employment, energy security, and economic benefits. Any industrial strategy must be built against a realistic evaluation of the comparative advantages of different production locations, and the measures the EU can use to create fair competition.

These have been evaluated this through the following seven qualitative factors. The European context was compared to the US and China due to their global prominence in SAF production and demand. The following factors were considered:

- **Used Cooking Oil:** This is a key feedstock for the HEFA process and is also widely used for Renewable Diesel production. Availability of this feedstock is key to scaling the HEFA pathway.
- **Cost of electricity:** Electricity is an input to all types of SAF production but is particularly important for synthetic SAF production.
- **Cost of natural gas:** Natural gas is an input for several SAF production approaches, particularly the HEFA and AtJ pathways.
- **Low carbon electricity:** The carbon intensity of the electricity impacts the CI for the SAF produced and is essential to ensure any synthetic SAF production reduces overall emissions.
- **Construction costs**: Impacting the capital costs for any retrofit or greenfield builds.
- **Refinery expertise:** Experience in refining is an important skillset for SAF production, and also represents the workforce that would benefit from a SAF industry providing a high-value transition opportunity.
- **Permitting simplicity:** Represents the ease for producers to build new capacity

Many additional factors are important for SAF developers, but this selection provides a diverse indication of the opportunities and challenges the underlying environment offers to a sustainable fuels industry.

[37] https://commission.europa.eu/topics/strengthening-european-competitiveness/eu-competitiveness-looking-ahead_en#paragraph_47059

Table 1: Comparing seven metrics for sustainable fuel developers in the EU, US, and China

Metrics	EU	US	China	Description
Access to UCO feedstock				Europe collected 0.8 Mt UCO in 2023, compared to 1 Mt in the US and 3.4 Mt in China
Cost of electricity				EU average electricity price of $0.24/kWh, compared to $0.18/kWh in the US and $0.07/kWh in China
Cost of natural gas				EU average natural gas price of €0.55/m^3, compared to €0.13/m^3 in the US and €0.47/m^3 in China
Low-carbon electricity				EU average electricity emissions intensity of 244 gCO2/kWh, compared to 370 gCO2/kWh in the US and 581 gCO2/kWh in China
Construction costs				EU and US construction costs are similar, and between 70%-130% greater than in China
Refinery expertise				The EU refines 12 mmbpd, compared to 18 mmbpd in the US and 19 mmbpd in China
Permitting simplicity				Higher backlog of renewable projects in the EU compared to the US and China

Access to UCO feedstock

As UCO is the most common feedstock for SAF in the EU, it was selected as a comparator. Access to UCO varies significantly across regions, reflecting differences in vegetable oil use, collection infrastructure, and population. In 2023, Europe had an estimated 1.5 Mt of UCO available, with a collection rate of 53%, leading to 0.79 Mt of UCO collected.[38] The US, with a significantly larger availability of 2.8 Mt, collected only 1 Mt, achieving a much lower collection rate of 36%. In contrast, China demonstrated the highest collection rate of 57%, collecting 3.38 Mt of the 5.87 Mt estimated available. These differences suggest that while China is better positioned to supply larger volumes of UCO to meet SAF production needs, Europe could unlock untapped potential through targeted improvements in collection systems in the residential sector, where the collection rate is just 12% in EU.[39] Reducing reliance on imported feedstocks decreases the carbon intensity of the resulting SAF, as shipping feedstock from Asia contributes a non-negligible portion to the overall lifecycle emissions.

Cost of electricity

Electricity prices are a critical factor influencing operating costs for SAF facilities, particularly synthetic SAF facilities. In 2023, the EU reported the highest average electricity price at €0.235 per kWh. The US had an

[38] https://www.transportenvironment.org/articles/european-and-us-used-cooking-oil-demand-increasingly-unsustainable-analysis
[39] https://www.transportenvironment.org/uploads/files/TE_UCO-Study_Stratas_11062024_2024-06-17-103904_bjrt.pdf

electricity price of €0.162 per kWh, benefiting from diverse energy sources and lower grid transmission costs. Meanwhile, China exhibited the lowest electricity price at €0.068 per kWh.[40]

Cost of natural gas

The price of natural gas for non-commercial users was highest in the first half of 2024 in the EU, where the average price across the 27 member states was €0.55 per cubic meter.[41] In China, the average price was €0.47 per cubic meter.[42] The United States had the lowest average price at just €0.13 per cubic meter, benefiting from abundant domestic natural gas reserves and competitive market dynamics.[43]

Low-carbon electricity

In the EU just over 44% of the electricity produced is renewable electricity, with only 16% gas and 12% coal. This contributes to an average carbon intensity of 244 gCO2/kWh. Although this varies considerably depending on the country, with countries such as Sweden having an energy intensity as low as 41 gCO2/kWh and countries such as Poland with 662 gCO2/kWh. In the US, renewables contribute to 22.6% of electricity production, with 42% coming from natural gas. This results in a carbon intensity of 370 gCO2/kWh. In China, renewables make up 31% of electricity production – however, with coal contributing to approximately 60% of the grid, the overall carbon intensity is 581 gCO2/kWh.[44]

Construction costs

Facilities in the EU and the US are 70% to 130% more expensive to construct per unit of output capacity than those in China for solar PV, wind and battery manufacturing.[45] Additionally, operating expenses are significantly higher. These elevated costs are attributed to the greater expense of key inputs such as raw materials, electricity, and labour in these regions.

Refinery expertise

Europe is a major oil refining centre, with over 12 million barrels/day in capacity in 2023.[46] It has considerable refining expertise, especially in its refining centres – Germany, Italy, France and Spain.[47] The US and China, have current refining capacities of over 18 million and 19 million bbl/day, respectively.[48] China's refining capacity is growing and in 2024 exceeded the refining capacity of the US. China's refining capacity exceeds its domestic demand, so China will either begin to export significant volumes of product or stockpile.[49] The US refining capacity has recently expanded, largely due to expansions of existing facilities.[50] The US has also seen significant

[40] https://worldpopulationreview.com/country-rankings/cost-of-electricity-by-country
[41] https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Natural_gas_price_statistics
[42] https://www.ceicdata.com/en/china/price-monitoring-center-ndrc-36-city-monthly-avg-transaction-price-production-material/cn-usage-price-36-city-avg-natural-gas-natural-gas-for-public-service-sector
[43] https://www.eia.gov/dnav/ng/ng_pri_sum_a_EPG0_PIN_DMcf_m.htm
[44] https://ember-energy.org/latest-insights/global-electricity-review-2024/major-countries-and-regions
[45] https://iea.blob.core.windows.net/assets/7e7f4b17-1bb2-48e4-8a92-fb9355b1d1bd/CleanTechnologyManufacturingRoadmap.pdf
[46] https://ycharts.com/indicators/europe_oil_refinery_capacities
[47] https://www.sciencedirect.com/science/article/pii/S235248472201335X
[48] https://www.eia.gov/todayinenergy/detail.php?id=62624
[49] https://www.spglobal.com/commodity-insights/en/news-research/latest-news/crude-oil/022924-chinas-refining-capacity-to-cross-19-mil-bd-in-2024-throughput-up-2-on-year-etri
[50] https://www.eia.gov/todayinenergy/detail.php?id=62624

conversion of existing refining capacity to biofuel processing, largely due to supportive policies offered through state-level and federal regulation and tax incentives.[51]

With over 50 years more experience as major oil refining regions, the EU and the US have the benefit of a long legacy of expertise in the refining industry.[52] However, China has rapidly accelerated its refining industry since the 1970s, whereas refining capacity in Europe is decreasing, with 1-1.5 million bbl/d at risk of closure by 2030, driven by decreasing refinery margins and a shift towards green energy.[53] Several European refineries have been converted to biofuel plants to take advantage of the more certain future demand for renewable fuels. This presents an attractive opportunity for refineries in pivoting to co-processing or retrofitting of existing facilities to support HEFA SAF production. On the other hand, biofuel margins have also recently dropped in Europe, which has led to a decrease – at least temporarily – in investment interest in European renewable fuel projects, and a need for supportive policies to stabilise supply and demand for domestic renewable fuel in the EU.

Permitting simplicity

The complexity of the industrial permitting process in the EU is largely regarded to be a barrier to the progress of renewable energy projects in Europe compared to competing regions.[54] This has been acknowledged by the EU, which has recently taken steps to simplify and accelerate permitting for renewable energy projects, including through the revised RED III.[55]

The backlog of offshore wind projects in our three comparator areas – the US, China, and the EU – can be used as a proxy for the ease of securing permitting approval for renewable projects in each region. 81% of European renewable wind capacity is stalled in the permitting process, compared to 79% in the US and 74% in China.[56] Permitting is considered to be more of an impediment to renewable project development in the US than in China, with the Biden government and industry stakeholders calling for permitting reform to ensure the US remains competitive with China in the renewable energy industry.[57]

Section summary: SAF Fundamental Drivers

1. The EU has considerable volumes of UCO available, although both the US and China have much greater domestic supply (collected and total opportunity).
2. EU SAF producers are (on average) at a cost disadvantage for many inputs, including the cost of electricity, natural gas, and for construction.
3. The EU has much lower carbon intensity in the electricity grid than both the US and China. However (as discussed in the next section) the structure of the ReFuel Mandate only values the CI reduction up to the GHG threshold. The delegated act ensures synthetic SAF production uses additional renewable electricity, although this also only partially accounts for the context of the wider grid.
4. The EU has considerable refining infrastructure and the associated workforce. The SAF industry provides a valuable pathway for these jobs to transition to the green economy, and can in-turn benefit from the considerable experience and infrastructure.

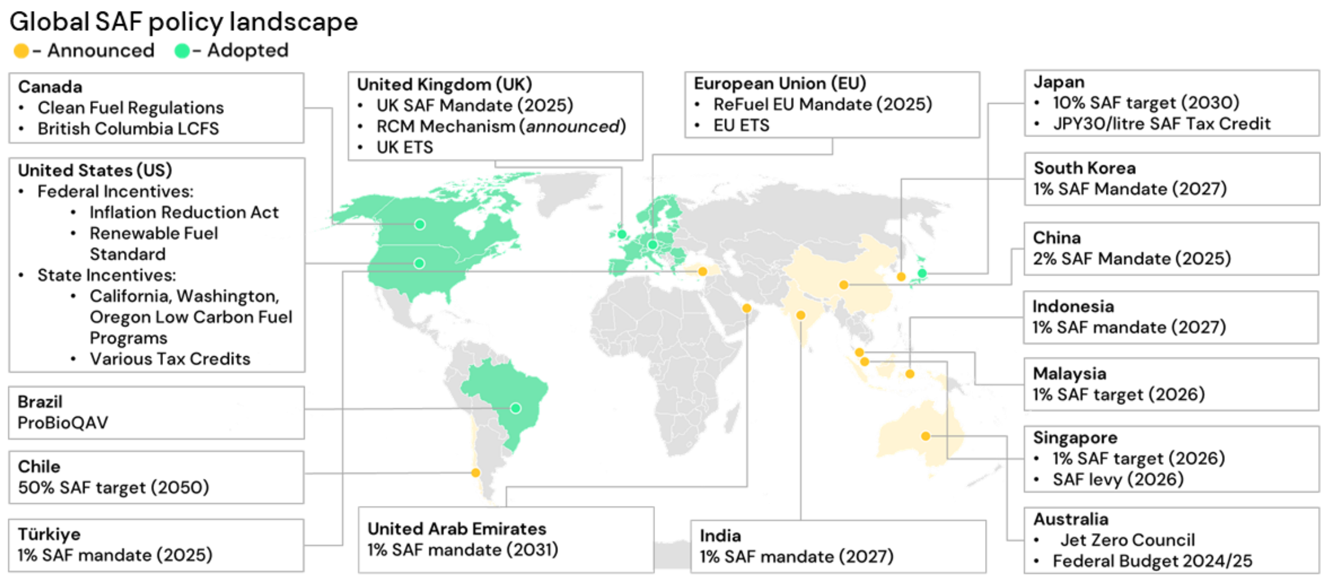
[51] https://www.instituteforenergyresearch.org/international-issues/china-vs-u-s-refining-industry/
[52] https://fingfx.thomsonreuters.com/gfx/editorcharts/gjnvwwxmjvw/
[53] https://www.spglobal.com/commodity-insights/en/news-research/latest-news/crude-oil/071824-europes-refining-sector-braces-for-major-downsizing-as-margins-stall
[54] https://www.weforum.org/stories/2024/09/wind-energy-permitting-processes-europe/
[55] https://energy.ec.europa.eu/topics/renewable-energy/enabling-framework-renewables_en
[56] https://www.weforum.org/stories/2024/09/wind-energy-permitting-processes-europe/
[57] https://www.instituteforenergyresearch.org/regulation/permitting-reform-still-being-discussed-with-different-priorities-among-the-players/; https://www.nationalreview.com/2024/02/government-regulations-are-making-the-u-s-lose-the-future-of-energy-to-china/

4.2 SAF market policy drivers

4.2.1 Key international policies

Policy initiatives are playing a crucial role in driving demand for SAF, creating a complex and evolving landscape across different regions. The EU and UK are global leaders in setting mandates for fuel suppliers requiring increasing percentages of SAF blending into conventional jet fuel, setting clear targets for adoption and providing a strong market signal. The US has focused on policy support mechanisms to incentivise SAF production and use. This regional patchwork of policies is creating a dynamic environment for SAF development, with each market employing unique strategies to accelerate the transition to more sustainable air travel.

SAF policies have emerged around the world, with the EU and UK leading demand and the US leading supportive incentives



Source: ICF Analysis

United Kingdom

The UK SAF mandate, which has come into effect on January 1, 2025, obligates fuel suppliers to provide increasing proportions of SAF. Certificates are awarded for the use of SAF with the number of certificates proportional to the carbon intensity of the SAF. In 2025, fuel suppliers must submit certificates equivalent to 2% of their total jet fuel supply. This is equivalent to 2% of their total jet fuel supply by volume being SAF with a carbon intensity of 26.7 gCO2e/MJ. Providing SAF with lower carbon intensities results in extra certificates and therefore lower required volumes. This mandate increases to 10% in 2030 and 22% in 2040. Within this mandate there is a sub-mandate for Power-to-Liquid (PtL) SAF of 0.2% by 2028, rising to 0.5% by 2030 and 3.5% by 2040. Additionally, there is a cap on the amount of HEFA that can contribute towards the mandate of 7.1% in 2030 and 7% in 2040. Failure to meet these targets results in a buy-out fee of £5,875/tonne SAF and £6,250 / tonne PtL SAF.

A frequently cited challenge delaying SAF production projects from reaching FID is the difficulty in securing long-term (15 years or more) offtake agreements due to the uncertainty in the future SAF market price. To address this, the UK has announced their intention to introduce a revenue certainty mechanism, that will work similarly to the Contracts for Difference model that has been successfully used in the renewable electricity market. This scheme, set to be launched in 2027, guarantees a fixed price thereby compensating for market fluctuations, reducing the risk profile of SAF projects, and offering greater assurance to debt financiers.

The UK also provides significant financial support initiatives, such as the Advanced Fuels Fund, which has allocated £165 million for new SAF production projects.

United States of America

The US is leading the SAF industry with both the highest level of ambition and the greatest monetary policy support. The cross-government SAF Grand Challenge aims for 3 billion gallons SAF by 2030, and full replacement of fossil fuels with SAF by 2050. A series of federal and state-level policies exist to incentivise SAF production. These incentives can be stacked, thus considerably reducing the premium of SAF over fossil jet fuel.

Federally, the CFPC credit contained within the Inflation Reduction Act (IRA), lasting until the end of 2027, offers tax credits for SAF production, that scale to $1.75/gallon for SAF with a 100% emissions reduction. Additionally, SAF is eligible to generate credits under the Renewable Fuel Standard. The federal government also offers a series of grant/loan guarantee programs, which can be leveraged for developing SAF technologies. The IRA includes a $244 million dedicated SAF grant funding through a new U.S. Department of Transportation program. The DOE and other agencies also offer loan guarantees and grant programs, although these can be challenging to access.

State policies complement those on the U.S. federal level. These include the Low Carbon Fuel (LCF) programs like those in California, Oregon, and Washington, which are mandates to reduce the carbon intensity of the fuel pool. In these schemes, SAF is eligible to earn credits, but is not a mandated fuel category. Numerous states have additional policies in place to incentivise SAF production.

- **Washington** provides a tax credit of $1 per gallon of SAF with at least 50% lower CO_2 emissions than conventional jet fuel, increasing by $0.02 for each additional 1% reduction, alongside a reduced business tax rate for SAF manufacturers, effective for 10 years starting July 2024 once a facility producing 20 million gallons per year is operational.
- **Illinois** offers a $1.50 per gallon SAF purchase credit for airlines operating in the state until 2033.
- **Minnesota** provides a $1.50 per gallon SAF production or blending credit for SAF used on flights departing the state, as well as sales tax exemptions for SAF facility construction, lasting until 2035.

Rest of the World

A growing number of countries globally have recognised the considerable co-benefits of establishing a domestic SAF production industry such as energy security, pass through-economic benefits, job creation and waste management. This has spurred many countries that have considerable quantities of potential SAF feedstocks, to move up the economic value chain and move from being a net exporter of feedstock to a SAF production hub. Countries that have announced the intention to introduce a SAF mandate include China, with its considerable lipid feedstock, Malaysia and Indonesia with their large volumes of palm oil, India with its considerable potential of MSW and UCO, Brazil with its large cellulosic ethanol industry and established biofuel industry, UAE with considerable potential for PtL, as well as Türkiye, Australia, Singapore, Japan, South Korea, Chile and Canada. This list is expected to grow in the coming years, increasing SAF demand and reducing quantities of feedstock that will be available for import to the EU.

4.2.2 Key European policies

- **ReFuelEU Aviation Regulation,** contained within the Fit for 55 package, includes a SAF mandate which came into effect on January 1, 2025. This mandate creates an obligation on fuel suppliers to supply an increasing share of SAF at large and mid-sized Union airports (annual passenger traffic exceeding 800,000 or over 100,000 tonnes of freight handled annually)[58] and includes a sub-mandate for synthetic SAF. Airports located in the EU's outermost regions are exempt from this requirement. A ten-year transition period lasting to the end of 2034 has been proposed, potentially allowing suppliers to supply the mandated levels of SAF as a weighted average across the EU, rather than at each airport within the scope. Fuel suppliers in the EU that fail to comply with the ReFuelEU Aviation mandate would have to pay a non-compliance penalty equal to at least double the price difference between conventional fuel and the applicable SAF type. Any revenues generated by fines will be used by EU member states to support R&D in the field of SAF or for other mechanisms to bridge the difference in price with conventional fuel. The fuel supplier will still have to supply the SAF volume the following year.
- Under the **European Union Emission Trading System** (EU ETS) the use of eligible SAF by commercial aircraft operators[59] does not result in the surrendering of allowances, as no additional CO_2 emissions are deemed to be released upon combustion. This in effect increases the cost of using fossil jet fuel, incentivising SAF use.
- From the period of 1 January 2024 to 31 December 2030, 20 million **SAF allowances** are reserved under the EU ETS to be distributed to aircraft operators who use SAF and other non-fossil derived aviation fuels. These allowances are aimed to cover part, or all, of the SAF price premium. The percentage of the price differential covered is dependent upon the category of SAF, ranging from 50 to 95%. Assuming an average carbon allowance price of €80, this amounts to a funding of approximately €1.6 billion[60].
- The **European Taxation Directive** (ETD) sets a minimum tax rate on fuels in the latest revision proposed by the European Commission. Under proposed revisions in 2025, conventional fossil-based jet fuel, which is currently exempt from taxation for intra-EU flights, may gradually be taxed, except for cargo flights, reaching a minimum rate of €10.75 per gigajoule (i.e. 0.37 €/l) in 2033. SAF will benefit from reduced or zero tax rates to incentivise their adoption, thus increasing the comparative cost of using fossil jet fuel.
- The EU offers several funding programs to support SAF-related projects, including the **ETS Innovation Fund**, which finances innovative low-carbon technologies, like advanced SAF production pathways, and has awarded €7.2 billion to over 120 projects, and has awarded €321 million to several large-scale projects; **Horizon Europe**, which funds research and development for breakthrough technologies, including SAF related projects; and the **Recovery and Resilience Facility** (RRF), which provides funding for green projects, including SAF, as part of post-COVID pandemic recovery efforts.

[58] https://transport.ec.europa.eu/document/download/4d913f70-d2ef-4d56-b3c0-376a249547b5_en?filename=ReFuelEU_list_airports_2025_reporting.pdf
[59] Assuming the operators have an ETS obligation, and recognising the proportionality allocation
[60] https://climate.ec.europa.eu/eu-action/transport/reducing-emissions-aviation_en

- Financial instruments under **InvestEU** can provide blended finance for high risk and high CAPEX projects and de-risk investments into SAF.
- The **European Hydrogen Bank** aims to accelerate the hydrogen economy by guaranteeing the purchase of hydrogen categorised as a renewable fuel of non-biological origin. By offering long-term purchase agreements, the EHB ensures market stability and de-risks investments in low-carbon hydrogen production, which is necessary PtL SAF.
- The **2022 Guidelines for State Aid for Climate, Environment, and Energy** (CEEAG) provides a framework for member states to grant state aid in support of projects that advance climate, environmental, and energy goals, including SAF production and infrastructure. By creating a more flexible framework for granting state aid, the guidelines enable governments to offer substantial financial backing for domestic SAF facilities.
- The **Net Zero Industry Act** (NZIA) aims to boost domestic manufacturing of clean technologies, aiming for at least 40% of the EU's deployment needs to be met locally by 2030. SAF is recognized as a net-zero technology under this initiative, which aims to create a simplified regulatory environment that will reduce the administrative burden of net-zero technology projects, facilitate market access for net-zero products and support skills development.
- The **EU Taxonomy for Sustainable Activities** establishes a classification system for environmentally sustainable economic activities, providing clear criteria to guide investments that align with the EU's climate and environmental objectives. While some SAF activities qualify, extending the definition across the value chain would support greater private capital to invest in the industry.

Section summary: SAF Policy drivers

- The US leads in providing financial support for SAF production through monetary incentives.
- The EU is a leader in driving demand through mandates and providing support for SAF producers through funding.
- Many countries are actively exploring the implementation of SAF mandates.
- Recognising the impact of price volatility on SAF project financing, the UK is introducing a Revenue Certainty Mechanism to stabilise prices, mitigate market risks, and improve investor confidence by providing greater assurance to debt financiers.

4.3 Implications for Europe

- **EU HEFA competitiveness:** Currently HEFA is the only commercially produced SAF in Europe, and HEFA SAF is expected to be the main contributor to meeting ReFuelEU Aviation targets. Europe is reliant on imports for its HEFA feedstocks, importing 80% of the total UCO used for biofuel, with 60% of these coming from China and a considerable portion from Indonesia and Malaysia[61]. Given that these countries are in discussions regarding introducing their own SAF mandates, and with an increase in announced SAF facilities

[61] https://www.transportenvironment.org/uploads/files/TE_UCO-Study_Stratas_11062024_2024-06-17-103904_bjrt.pdf

in these regions, the quantity of HEFA feedstocks available for export to Europe is likely to reduce over time. The resulting impact on the European SAF market could be significant, since a reduction in feedstock availability will lead to increased costs for existing production facilities and increased delays in securing FIDs for new facilities. An aggressive Chinese SAF policy in particular could have considerable knock-on effects for Europe if implemented. This emphasises the need to scale advanced SAF technology pathways.

Strategic Consideration:

Given the limited availability of HEFA feedstocks and the potential reduction in Asian-based feedstock supplies, the EU will increasingly rely on advanced SAF technologies to meet ReFuelEU Aviation targets beyond 2030. Despite this growing necessity, the development and deployment of advanced SAF technologies within the EU remain limited. While AtJ production is reaching commercial deployment in the US, these facilities utilise food crop-based ethanol, which is not eligible under ReFuelEU Aviation. Although this progress de-risks the ethanol-to-SAF technology, the EU must prioritise the demonstration of non-food-based ethanol production processes. Successfully demonstrating cellulosic ethanol will be critical to scaling AtJ SAF production in the EU. Commercialisation of facilities using the Fischer-Tropsch (FT) and other processes are similarly crucial.

Achieving this will ensure the SAF supply can achieve the rapid scaling in demand required to meet the later stages of the ReFuelEU Aviation mandate. The technologies used for these advanced SAFs (AtJ, FT, etc) are also used for synthetic SAF production, providing an important transition mechanism.

The primary challenges advanced SAF facilities face in securing financing is the uncertain future SAF market prices, high capital investments and technology risks due to the lack of commercial-scale deployment. To overcome these challenges, additional support mechanisms are crucial to accelerate deployment and mitigate financial risks for developers to secure financing.

- **Synthetic SAF:** Over 40 synthetic SAF facilities have been announced in the EU, with a cumulative SAF production volume of approximately 1.5 Mt. However, given that none of these facilities have reached FID, and over three-quarters are yet to start front-end engineering design (FEED) studies, ICF forecasts that in a central scenario there will be approximately 0.2 Mt of synthetic SAF production in Europe by 2030, with 0.07 Mt and 0.75 Mt in low and high scenarios. This is in general agreement with Project SkyPower's assessment that approximately 0.3 Mt of synthetic SAF capacity is on-track to be operational by 2030, with an additional 0.5 Mt that requires considerable support to be operational by 2030[62]. The ReFuelEU Aviation sub-mandate requires a minimum of 0.7% of fuel to be synthetic SAF in 2030 with the average uplift of 1.2% between 2030 and 2031, equivalent to approximately 0.33 Mt and 0.57 Mt respectively, based on current jet fuel consumption forecasts. Furthermore, due to the non-existence of mandates or additional incentives for synthetic SAF in the US or Asia, it is unlikely that significant quantities of PtL SAF will be produced outside of the EU will be available to fill the gap.

[62] https://project-skypower.org/news-publications/accelerating-take-e-saf-europe

Strategic Consideration:

The lack of investment, absence of facilities reaching FID, and limited availability of imports highlight the risk of a potential shortfall in synthetic SAF supply by 2030 if additional support measures are not implemented. This shortfall would impose substantial costs on the aviation sector, driven by high synthetic SAF prices and heavy fines for non-compliance with regulatory obligations, while delivering only limited environmental benefits.

To address this the EU must implement targeted financial and regulatory measures to reduce investment risk and accelerate capacity development. Synthetic SAF faces considerable price volatility due to its reliance on fluctuating renewable electricity costs, less mature technology, and lack of commercial deployment. As a result, debt investors are reluctant to provide financing for synthetic SAF projects, leading to delays in FID.

- **Levelling the international market:** In the US, SAF providers can claim multiple federal and state incentives. This value stack makes the US the most economically attractive region in which to sell SAF and has resulted in airlines focusing their efforts on US-based SAF uplift. Even after the BFC transitions to the CTFC, the US is likely to remain a more attractive market for SAF purchase than Europe. This competitive advantage has implications for the global SAF supply chain. Producers or suppliers of SAF and feedstocks from regions such as South America and Southeast Asia can access plentiful feedstocks, cheap inputs, and developing infrastructure to produce SAF at competitive prices compared to European refineries.

Strategic Consideration:

This highlights the urgent need for the EU to strengthen its SAF market competitiveness through targeted policies and strategic investments. Enhancing financial support, streamlining regulatory processes, and improving logistical frameworks will be essential to attract sufficient SAF production and feedstock supply. To mitigate the risk of HEFA feedstock shortages and ensure the EU remains competitive in the global SAF market, it is critical to create a more appealing environment for both domestic production and international supply. With high renewable electricity penetration and strong demand signals, the EU could become a global leader in synthetic SAF industry if the appropriate supports are in place.

These challenges underscore the urgent need for an ambitious EU SAF industrial strategy to ensure energy security, meet ReFuelEU Aviation targets and maintain competitiveness in a rapidly evolving global SAF market.

5 Policy toolbox to catalyse EU SAF production

Addressing these challenges requires a coordinated and ambitious policy framework that enhances market efficiency, reduces investment risks, and accelerates the deployment of advanced and synthetic SAF technologies. Ensuring stable regulatory signals can create a more predictable and attractive environment for SAF producers and investors. By pursuing these market-oriented solutions alongside targeted supportive policies, the EU can strengthen its position in the global SAF market while meeting its long-term decarbonisation objectives.

5.1 Measures to mobilize capital for competitive SAF production

- **Reducing market risk**: Price volatility in SAF markets creates significant challenges for securing financing, as it undermines confidence in the long-term profitability of projects. Long-term offtake agreements, which provide predictable revenue streams, are crucial in demonstrating financial stability and reducing perceived risks for investors and lenders. However, these are uncommon currently due to the uncertainty in future SAF market prices.
- Introducing a mechanism to establish a fixed or floor price for advanced and synthetic SAF could effectively mitigate price volatility. Contracts for Difference, successfully used in the renewable electricity sector, bridge the gap between the market price and a pre-agreed strike price, offering revenue stability for producers and price certainty for financiers. In the UK's CfD scheme for renewable electricity, strike prices have, in many instances, fallen below the market prices[63]. This shows that CfDs enable governments to take on financial risk from projects to support financing, while not necessarily incurring a cost to taxpayers. The announced Revenue Certainty Mechanism in the UK, available exclusively for non-HEFA SAF, is likely to follow this approach.
- Alternatively, a Feed-in Tariff for SAF, which would operate similar to a SAF production credit mechanism, could address market risk by guaranteeing producers a fixed price per unit of SAF sold, independent of market fluctuations. This has been applied extensively in the renewable energy industry and provides predictable revenue streams, making projects more attractive to investors and financiers.
- Carbon Contracts for Difference (CCfD) could provide an attractive alternative mechanism that is tailored to the variation in emission reduction profiles across different SAF pathways. Unlike CfDs, CCfDs compensate producers for the carbon abatement gap, linking financial support directly to the emissions reduction potential of SAF. Germany has already introduced a CCfD scheme focused on decarbonising energy-intensive industries, such as steel, chemicals, and cement, by bridging the cost gap between low-carbon technologies and conventional production methods[64]. Several other Member States are in pilot stages or actively exploring similar initiatives.
- While the EU's 2022 CEEAG framework allows for flexible state-aid measures which can be used by Member States to promote domestic SAF production, it has resulted in disparities among member states due to varying levels of economic support. Implementing similar measures at an EU-wide level would enhance fairness, reduce market fragmentation, and scale up the overall impact of the scheme.

[63] https://www.gov.uk/government/publications/contracts-for-difference-cfd-allocation-round-6-results/contracts-for-difference-cfd-allocation-round-6-results-accessible-webpage
[64] https://www.klimaschutzvertraege.info/en/home

- **Focused investment support for advanced SAF facilities:** Under the current criteria, the ETS Innovation Fund categorises projects as small-scale (capex < €20 million), medium scale (capex <€100 million) and large-scale (capex > €100 million). Given the high capital costs of SAF facilities, these projects are categorised as large-scale and must compete with industries like green steel and cement production. However, SAF facilities are often at a disadvantage under the *Cost Efficiency* criterion due to their higher carbon mitigation costs as first-of-a-kind facilities and their lower relative carbon abatement compared to the large-scale emissions reductions achievable in steel or cement projects. To ensure fair competition and a level playing field, an aviation-specific category should be introduced, or an aviation-specific call announced, allowing SAF projects to be evaluated and compared against other aviation-related initiatives, rather than against unrelated industrial sectors.
- A number of adjustments to the Award Criteria of the ETS Innovation Fund would result in a more favourable and fair scoring for not only SAF projects but for projects with benefits that extend beyond energy. For example, giving a greater scoring for criteria that reward projects that integrate multiple early-stage technologies and have cross-sectoral benefits. This would benefit synthetic SAF facilities while helping to scale green hydrogen and carbon capture technologies.
- While SAF production, especially synthetic SAF, is currently expensive, it holds significant potential for future cost reductions through technological innovation, scaling, and efficiencies. Awarding additional points for projects that clearly demonstrate pathways to cost competitiveness over time would reflect the potential future savings of scaling advanced and synthetic SAF technologies. Domestic SAF production enhances energy security by reducing reliance on imported SAF and fossil fuels. Introducing a "strategic importance factor" could recognise projects that contribute to the EU's energy independence goals and aid EU technology competitiveness.
- Aviation is a uniquely hard-to-abate sector, with limited alternatives for decarbonisation, unlike in on-road transportation. Additionally, aviation is tasked with higher sustainability criteria that other transport sectors and a unique mandate on synthetic fuels. Adding an extra bonus point for aviation-focused projects in the ETS Innovation Fund award criteria would acknowledge the complexity of the decarbonisation challenge, similar to the bonus point for the maritime sector.
- The Strategic Technologies for Europe Platform (STEP) aims to facilitate funding from multiple programs for high-quality projects by awarding the "Step Seal". STEPs evaluations should prioritize SAF projects as strategic assets essential to the EU's decarbonization and energy security objectives, especially those advanced SAF technologies that are essential to the industry's development. By granting these projects the STEP Seal, this can elevate their visibility, access multiple funding streams and attract private capital.
- Other countries have used similar programs to effectively support SAF. In the US, over €239 million ($291 million USD) has been awarded to 36 projects under the FAA FAST SAF program, the UK which has awarded over €178 million (£150 million) to 22 projects under the Green Fuels, Green Skies and Advanced Fuels Fund schemes, Australia which has awarded nearly €14 million ($23.1 million AUD) to 3 projects under the Australian Renewable Energy Agency (ARENA) program and in Japan over €1 billion (168.5 billion yen) has been awarded under the Green Innovation Fund to a project that involves the production of SAF.

- **Recognising the value of renewable naphtha:** The inclusion of chemicals as a focus area in the Clean Industrial Deal presents an opportunity to provide an additional revenue stream for SAF producers and reduce the SAF premium by recognising the value of renewable naphtha. This is particularly important in synthetic SAF facilities where SAF bears the majority of the production cost premium, as synthetic naphtha does not command a significant price premium over fossil naphtha in the market. Recognising the low-carbon attributes of naphtha could improve the business case for SAF facilities by creating additional revenue streams, as illustrated by IKEA's purchase of renewable naphtha from Neste for plastic production.[65]

- **Ensuring feedstock access.** Biogenic wastes and residues should be prioritised for sectors with few alternatives, for example by adjusting the waste hierarchy to prioritise the use of biogenic wastes for SAF production over incineration. Adjustments to the waste hierarchy could support SAF production to access non-recyclable municipal solid wastes (and reduce landfill and air pollution from incineration). Utilising the biogenic component of MSW for SAF offers significantly greater energy efficiency compared to incineration with energy recovery ("Waste-to-Energy"). This could be done by amending the Waste Framework Directive to classify SAF as a preferred method of recovery over Energy-to-Waste for biogenic components of MSW. Given the considerable MSW produced in the EU (c. 5t per citizen per year[66]), with over a fifth currently sent to landfill[67], this technology has potential to address multiple challenges in the EU and may warrant additional support through measures to encourage the separation of biogenic components of MSW and targeted funding for MSW-to-SAF infrastructure. Fossil CO2 use could be extended beyond 2041 for producers that commission in advance, ensuring sufficient time to achieve the payback period.

- Meeting the synthetic SAF sub-mandate will require considerable electricity, and this must be accounted within the EU's energy supply plans. Mechanisms should ensure producers can access electricity at globally competitive prices. In the EU, electricity prices are among the highest in the world. Due to the electricity-intensive nature of synthetic SAF production, a considerable portion of the SAF price comes from feedstock costs. Considering the low cost of renewable electricity in regions such as China, it is important to help minimise these prices if domestic production is to scale and remain competitive. Such initiatives could include reducing or exempting SAF production facilities from electricity-related taxes, fees, and levies.

5.2 Measures to increase efficiency of existing mechanisms

- **Ensure an efficient market through a book and claim mechanism.** The ReFuelEU Aviation obligation currently requires both physical SAF and environmental attributes (including ReFuelEU Aviation compliance tickets) to be mass-balance allocated to Union airports. While this allocation has some benefits, a system which allows obligated parties to trade some portion of the compliance tickets independently from the physical fuel (e.g. through a book and claim mechanism), could facilitate market efficiency and price reductions. Such a system would encourage the construction of SAF facilities in regions where production

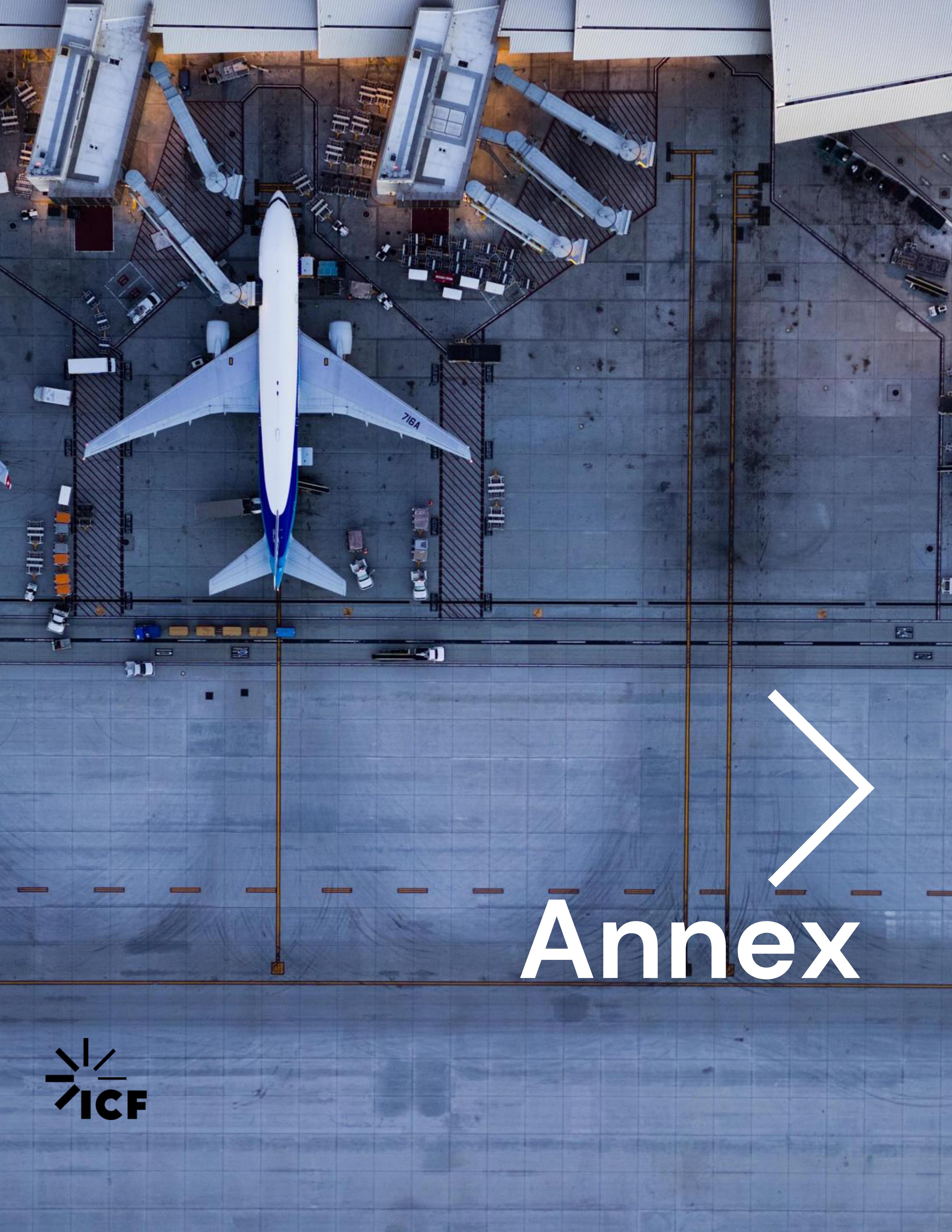
[65] https://www.neste.com/news/neste-and-ikea-of-sweden-announce-partnership-to-deliver-renewable-bio-based-plastics
[66] https://www.eea.europa.eu/en/topics/in-depth/waste-and-recycling?activeTab=fa515f0c-9ab0-493c-b4cd-58a32dfaae0a
[67] https://environment.ec.europa.eu/topics/waste-and-recycling/waste-framework-directive_en

is most cost-effective and reduce the market power of the incumbent companies that control the fossil fuel value chain. This would need to be carefully coordinated with the ETS claims and scope 3 allocations.

- **Refining the ReFuelEU Aviation Mandate.** The mandate for fuel suppliers includes 5-year steps, each with abrupt increases. SAF is supplied through large infrastructure projects, which are slow to build and align to this profile. Smoothing the increases would limit the under or over-supply of SAF and the resulting market volatility.

- **Commercialising advanced SAF (Annex IX Part A).** HEFA SAF, using UCO and waste tallows from Annex IX Part B of Directive (EU) 2018/2001 on the promotion of the use of energy from renewable sources (RED II), provides an effective foundation for the SAF industry. However, technologies to commercialise advanced feedstocks in Part A of the annex have not been able to compete due to higher production costs and risk profiles. Existing measures should be amplified by providing revenue certainty, providing targeted support, allowing bankable offtake through improvements to the ETS allowance scheme, and increasing their multiplied contributions under the RED (currently 1.2x energy content, compared to 1.0x for Part B). This support is crucial to reduce dependence on constrained feedstocks and diversify the production opportunities.

These recommendations are designed to address the key challenges the EU must face to meet the ReFuelEU Aviation ambition. They aim to ensure that the required emissions reductions are effectively achieved, European aviation maintains competitiveness on the international stage, and energy security is enhanced. A strong and forward-looking industrial policy via the new EU Clean Industrial Deal is essential to seize the opportunity, and we hope this report can provide a blueprint for improvements that can ensure the EU's environmental and economic leadership.



Annex

Detailed SAF Policy Outlook

Efforts to reduce carbon emissions in the international aviation industry have been driven by the International Civil Aviation Organization (ICAO), primarily through the Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA).

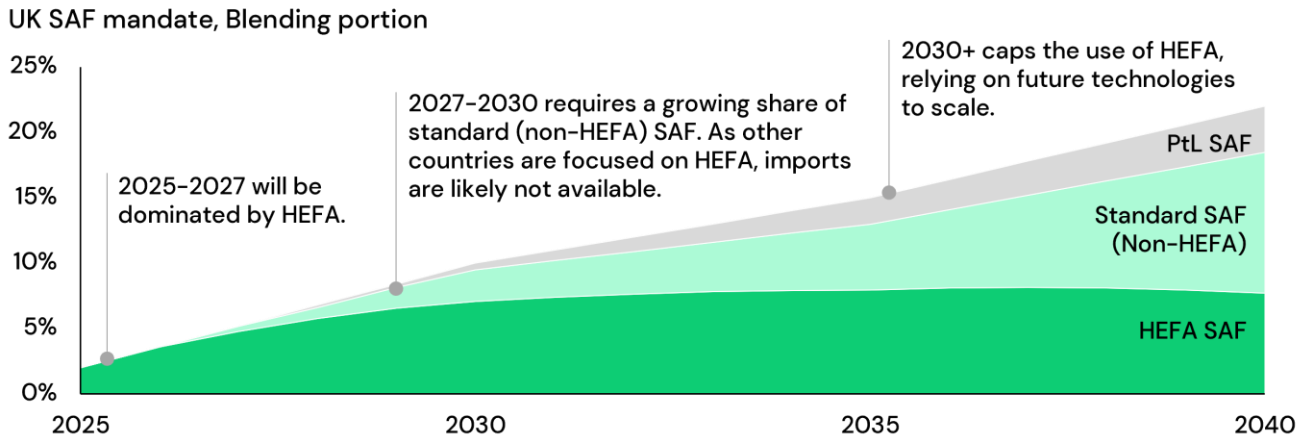
- **ICAO**: In October 2022, the member states of ICAO adopted a collective long-term global aspirational goal (LTAG) of achieving net-zero carbon emissions from international aviation by 2050. This ambitious target signifies a shared commitment to significantly reduce and ultimately eliminate carbon emissions from the aviation sector to mitigate climate change impacts. To support the realisation of this goal, member states also endorsed the new ICAO Assistance, Capacity-building, and Training for Sustainable Aviation Fuels (ACT-SAF) program. This program aims to facilitate the development and adoption of SAF to achieve the net-zero emissions objective by 2050. Additionally, at the Third ICAO Conference on Aviation and Alternative Fuels (CAAF/3), governments from over 100 States adopted a collective goal to reduce aviation fuel's carbon intensity by 5% by 2030, primarily through transitioning to SAF. This agreement marks a significant step towards the aviation sector's commitment to net-zero carbon emissions by 2050 and provides a global framework for SAF development and deployment.
- **CORSIA**: CORSIA is another ICAO initiative, designed to achieve carbon-neutral growth in the global aviation sector from 2021 to 2035 - with a baseline reference point set at 85% of the 2019 emission level. Airlines operating between participating countries are required to report emissions data and purchase and cancel 'emissions units' to offset the increase in CO_2 emissions between signatory countries covered by the scheme. SAF that meets CORSIA specifications, including a minimum greenhouse gas saving threshold of 10% against a fossil fuel baseline, can be used by airlines to reduce their CORSIA offsetting obligations.

Many countries are introducing SAF policies, with the U.S., EU, and the UK currently leading. These policies have typically been built by adjusting existing policies to decarbonise the road transport sector, although pressure from corporations and the wider public has led to the introduction of new policies to decarbonise aviation specifically.

United Kingdom

The UK SAF mandate, which is set to come into effect on January 1, 2025, obligates fuel suppliers to provide increasing proportions of SAF. Certificates are awarded for the use of SAF with the number of certificates proportional to the carbon intensity of the SAF. In 2025, fuel suppliers must submit certificates equivalent to 2% of their total jet fuel supply. This is equivalent to 2% of their total jet fuel supply by volume being SAF with a carbon intensity of 26.7 gCO2e/MJ. Providing SAF with lower carbon intensities results in extra certificates and therefore lower required volumes. This mandate increases to 10% in 2030 and 22% in 2040. Within this mandate there is a sub-mandate for Power-to-Liquid (PtL) SAF of 0.2% by 2028, rising to 0.5% by 2030 and 3.5% by 2040. Additionally, there is a cap on the amount of HEFA that can contribute towards the mandate of 7.1% in 2030 and 7% in 2040. Failure to meet these targets results in a buy-out fee of £5,875/tonne SAF and £6,250 / tonne PtL SAF.

The UK SAF mandate obligates fuel suppliers to provide 2% SAF by 2025, 10% by 2030 and 22% by 2040 with a sub-mandate for power-to-liquid SAF



Source: https://www.gov.uk/government/speeches/sustainable-aviation-fuel-initiatives

A frequently cited challenge delaying SAF production projects from reaching FID is the difficulty in securing long-term (15 years or more) offtake agreements due to the price uncertainty of the resulting SAF. To address this, the UK has announced their intention to introduce a revenue certainty mechanism, that will work similarly to contract for difference contracts that have been successfully used in the renewable electricity market. This scheme, set to be launched in 2027, aims to unlock long-term offtake agreements by providing price stability for SAF producers. By guaranteeing a fixed price or compensating for market fluctuations, the mechanism reduces the risk profile of SAF projects, offering greater assurance to debt financiers and encouraging investment.

The UK SAF policy landscape also includes significant financial support initiatives, such as the Advanced Fuels Fund, which has allocated £165 million for new SAF production projects. The government aims to have five commercial-scale SAF plants under construction by 2025, reflecting its commitment to fostering a robust domestic SAF industry. These efforts are expected to create over 10,000 jobs and contribute approximately £1.8 billion annually to the UK economy.

United States of America

The US is leading the SAF industry with both the highest level of ambition and the greatest monetary policy support. The cross-government SAF Grand Challenge aims for 3 billion gallons SAF by 2030, and full replacement of fossil fuels with SAF by 2050. The Inflation Reduction Act (IRA) combined with existing federal policy (Renewable Fuel Standard) and state-level policies offer considerable incentives to SAF producers, closing the price premium of SAF over conventional jet fuel.

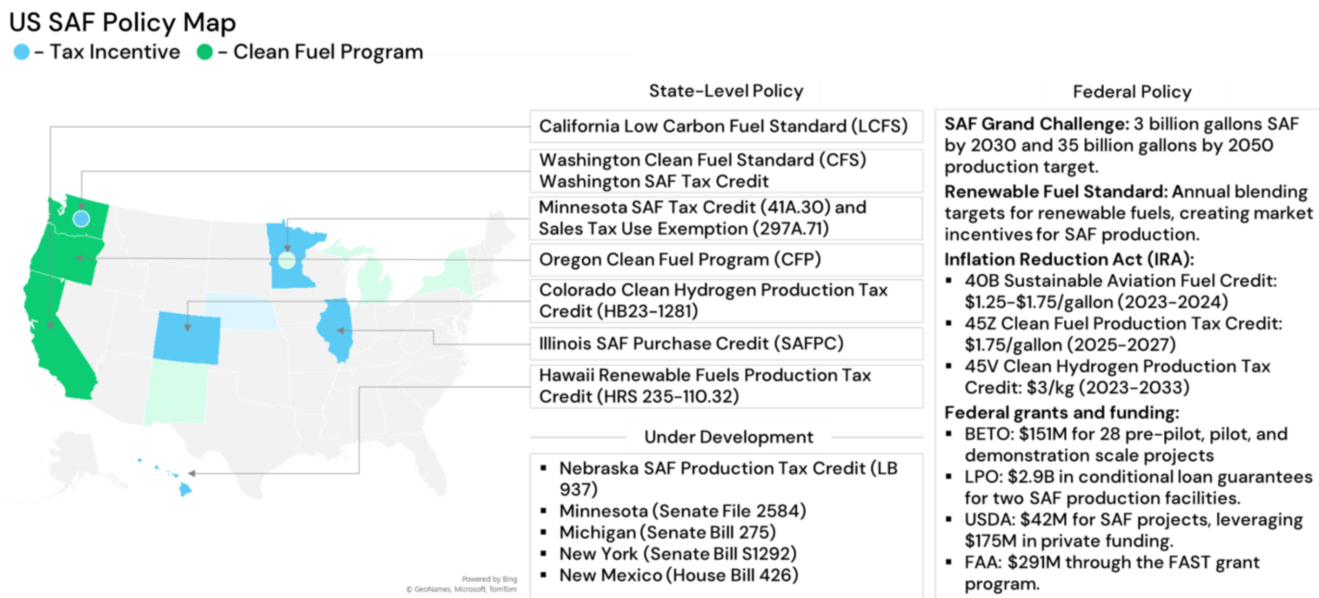
The RFS is the backbone of the U.S. SAF and biofuel industry. This policy is a mandate on fuel suppliers to include a specified volume of biofuels into the fuel supply, mainly focusing on road transportation. The RFS is designed with nested obligation categories, known as RINs. Each category has different feedstock and emission criteria, meaning that while the obligation is predominantly met by corn-derived ethanol, smaller volumes of more advanced renewable fuels are also mandated. Although fossil jet fuel is not an obligated category, SAF blended into the U.S. fuel pool generates compliance credits. Imported fuels are also eligible for blending and compliance with the RFS.

In 2025, the SAF BTC, which includes imported SAF, will transition to the CFPC, also known as Section 45Z, which lasts until 2027 and is only available to SAF produced in the US. The CFPC sets a baseline emissions factor for SAF at 50 $KgCO_2$/MMBTU (approximately 50% reduction), scaling to $1.75/gallon for SAF with a 100% emission reduction. Additionally, the IRA included two tax credits, the clean hydrogen production tax credit (45V) and the carbon capture and storage credit (45Q).

State policies complement those on the U.S. federal level. These include the Low Carbon Fuel (LCF) programs like those in California, Oregon, and Washington, which are mandates to reduce the Carbon Intensity (CI) of the fuel pool. SAF is eligible to earn credits, but is not a mandated fuel category, so these policies also act as incentives for SAF producers, funded by customers using other fuels (e.g. road fuels in California are c. $0.1/gal more expensive due to the policy). To date, there are three key additional, separate state incentives available in Illinois, Minnesota and Washington state:

- **Washington bill SB 5447 promoting the alternative jet fuel industry in Washington:** This bill provides incentives available for purchases of SAF for flights departing Washington State. It is equal to $1 for each gallon of alternative jet fuel that has at least 50% less CO_2e than conventional jet fuel and increases by $0.02 for each additional 1% reduction in CO_2e emissions beyond 50%. A SAF tax incentive to manufacture and purchase SAF was also implemented by creating a business and operations tax rate of 0.275% for the manufacture and sale of SAF. The tax incentive will go into effect July 1, 2024, but only after a facility capable of producing at least 20 million gallons of alternative jet fuel is operating in Washington. It will be applicable for 10 years.
- **Illinois Sustainable Aviation Fuel Purchase Credit:** This credit is available for every gallon of SAF sold to or used by an air carrier in Illinois. Airlines can claim a credit of $1.50/gallon of SAF that achieves a 50% reduction in GHG emissions and is only available to airlines operating in Illinois. The incentive is effective until June 1, 2033. By 2028, all fuel must be derived from domestic biomass resources.
- **Minnesota Sustainable Aviation Fuel Tax Credit:** The refundable tax credit provides $1.50 per gallon of sustainable aviation fuel produced or blended in Minnesota and sold for use in planes departing Minnesota airports. It further provides a sales tax exemption for construction materials and supplies to support the construction of facilities that produce or blend SAF. The tax credit expires on January 1, 2035.

The US is leading the SAF industry with the highest level of ambition and federal- and state-level incentives



Source: ICF Analysis

The US also offers a series of grant/loan guarantee programs, which can be leveraged for developing SAF technologies. The IRA included a $244 million dedicated SAF grant funding through a new U.S. Department of Transportation program. The DOE and other agencies also offer loan guarantees and grant programs, although these can be challenging to access.

Rest of the World

A growing number of countries globally have recognised the considerable co-benefits of establishing a domestic SAF production industry such as energy security, pass through-economic benefits, job creation and waste management. This has spurred many countries that have considerable quantities of potential SAF feedstocks, to move up the economic value chain and move from being a net exporter of feedstock to a SAF production hub. Countries that have announced the intention to introduce a SAF mandate include China, with its considerable lipid feedstock, Malaysia and Indonesia with their large volumes of palm oil, India with its considerable potential of MSW and UCO, Brazil with its large cellulosic ethanol industry and established biofuel industry, UAE with considerable potential for PtL, as well as Türkiye, Australia, Singapore, Japan, South Korea, Chile and Canada. This list is expected to grow in the coming years, increasing SAF demand and reducing quantities of feedstock that will be available for import to the EU.

5.2.1 Key European policies

- The **Fit for 55** package, announced in July 2021, included a set of proposals to make the EU's climate, energy, land use, transport and taxation policies fit for reducing net greenhouse gas emissions by at least 55% by 2030, compared with 1990 levels. The package included a recast of the Renewable Energy Directive (RED II), to ensure the EU delivers on their new target by ensuring at least 32% of its energy consumption comes from renewable energy sources by 2030. This also includes a target of a minimum 40% share in final energy consumption by 2030, accompanied by sectoral targets. It also included ReFuelEU Aviation, which introduced a set of policies to decarbonise aviation.

- **ReFuelEU Aviation,** contained within the Fit for 55 package, includes a SAF mandate on fuel suppliers which will come into effect on January 1, 2025. This mandate creates an obligation on fuel suppliers to supply an increasing share of SAF at Union airports. The required share of SAF that must be uplifted at each airport increases every 5 years, starting in 2025 with 2%, increasing to 6%, then 20%, 34%, 42% and 70% by 2050. This contains a sub-mandate for synthetic SAF starting in 2030 at 1.2%. A ten-year transition period lasting to the end of 2034 exists during which suppliers can supply the mandated levels of SAF as a weighted average across the EU, rather than at each airport within the scope. Fuel suppliers in the EU that fail to comply with the ReFuelEU Aviation mandate would have to pay a non-compliance penalty equal to double the price difference between conventional fuel and the applicable SAF type. Any revenues generated by fines will be used by EU member states to support R&D in the field of SAF or for other mechanisms to bridge the difference in price with conventional fuel. The fuel supplier will still have to supply the SAF volume the following year.
- The **European Emission Trading System** (EU ETS) is a system for greenhouse gas allowance trading within the Union to promote the reduction of greenhouse gas emissions through the imposing of a limit on the quantity of emissions permitted from various sectors, including aviation. Under the EU ETS, the use of eligible SAF by commercial aircraft operators does not result in the surrendering of allowances, as no Carbon Dioxide (CO_2) emissions are deemed to be released upon combustion. This in effect increases the cost of using fossil jet fuel, incentivising SAF use.
- From the period of 1 January 2024 to 31 December 2030, 20 million SAF **allowances** are reserved under the EU ETS to be distributed to aircraft operators who use SAF and other non-fossil derived aviation fuels. These allowances are aimed to cover part, or all, of the SAF price premium. The percentage of the price differential covered is dependent upon the category of SAF, ranging from 50 to 95%. Assuming an average carbon allowance price of €80, this amounts to a funding of approximately €1.6 billion.
- The **European Taxation Directive** (ETD) sets a minimum tax rate on fossil fuels. Under proposed revisions in 2025, conventional fossil-based jet fuel, which is currently exempt from taxation for intra-EU flights, will gradually be taxed, starting at a minimum rate of €10.75 per gigajoule. SAF will benefit from reduced or zero tax rates to incentivise their adoption, thus increasing the cost of using fossil jet fuel and reducing the SAF premium.
- The EU offers several funding programs to support SAF-related projects, including the **ETS Innovation Fund**, which finances innovative low-carbon technologies like advanced SAF production pathways; **Horizon Europe**, which funds research and development for breakthrough SAF technologies; and the **Recovery and Resilience Facility** (RRF), which provides funding for green projects, including SAF, as part of post-COVID pandemic recovery efforts.
- Financial instruments under **InvestEU** can provide blended finance for high risk and high CAPEX projects and de-risk investments into SAF.
- The **European Hydrogen Bank** aims to accelerate the hydrogen economy by guaranteeing the purchase of hydrogen categorised as a renewable fuel of non-biological origin. By offering long-term purchase

agreements, the EHB ensures market stability and de-risks investments in low-carbon hydrogen production, which is necessary PtL SAF.

- The **2022 Guidelines for State Aid for Climate, Environment, and Energy** (CEEAG) provides a framework for member states to grant state aid in support of projects that advance climate, environmental, and energy goals, including SAF production and infrastructure. By creating a more flexible framework for granting state aid, the guidelines enable governments to offer substantial financial backing for domestic SAF facilities.
- The **Net Zero Industry Act** (NZIA) aims to boost domestic manufacturing of clean technologies, aiming for at least 40% of the EU's deployment needs to be met locally by 2030. SAF is recognized as a net-zero technology under this initiative, which aims to create a simplified regulatory environment that will reduce the administrative burden of net-zero technology projects, facilitate market access for net-zero products and support skills development.
- The **EU Taxonomy for Sustainable Activities** establishes a classification system for environmentally sustainable economic activities, providing clear criteria to guide investments that align with the EU’s climate and environmental objectives. While elements of SAF production qualifies as a sustainable activity under the taxonomy, some elements of the value chain are excluded.

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