Sustainable Aviation Fuels: SAFs are paving the way for greener skies

Sustainable aviation fuels offer a greener future for aviation. But the costs are high, production is limited and the infrastructure is challenging. Even so, airlines have to meet tough targets, notably in Europe. Here's where the industry is right now and where it could be headed

Sustainable aviation fuels (SAFs) are derived from renewable resources, like biomass, waste oils, and even algae and they offer a promising alternative to traditional jet fuels. They have the potential to significantly reduce greenhouse gas emissions, making air travel more environmentally friendly. However, the future of SAFs is fraught with challenges. High production costs, limited availability of feedstocks and the need for extensive infrastructure development are significant hurdles.

In this bundle of articles, we look at where the industry is right now and where it's headed. We ask whether European airlines can meet tough EU-imposed targets. We look at how the US can become the world's leading producer of SAFs. And we examine Asia's role in this aviation revolution and examine why demand may be lacking in the APAC region.

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Europe leads the way on SAF, but airlines are struggling to hit targets

European airlines are leading the SAF charge

By Rico Luman, Thijs Geijer and 2 others

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APAC sustainable aviation fuel demand set to trail behind supply

The APAC region has a fair amount of SAF projects in the pipeline, but less is happening on the demand side

By Warren Patterson, Rico Luman and 2 others

Sustainable Aviation Fuels are the greener option that must take flight

Sustainable aviation fuels are the key mid-term solution to cut aviation emissions. Despite ambitious 2030 targets, blend rates remain low

Fuelling a private jet with SAF

SAF-route is indispensable to start reducing net-emissions in aviation

The aviation industry has faced extraordinary challenges in recent years but has rebounded strongly from the pandemic, with ongoing high demand for air travel, especially in Asia, where travel propensity is high despite flights per head being far lower than in the US, for example. A constant factor is the urgent need to reduce emissions, as the sector is among the hardest to abate. Its current 2% share* in global GHG emissions could quickly rise if no changes are made and demand reduction is ignored.

Most airline emissions come from longer-haul flights over 1,500 km. Realistically, there is no clean and commercially scalable alternative technology for longer journeys yet. With the highest safety standards and significant investments in R&D, introducing a new generation of aircraft usually takes up to 20 years, and order books for the current generation already extend well into the 2030s.

Fleet renewal programmes are a crucial part of airline strategies to reduce seat emissions. However, aircraft life cycles are long, there are delays, and these measures alone are insufficient. Therefore, sustainable aviation fuels (SAF) play a critical role in making flying more sustainable despite concerns about sourcing, efficiency, and the required lifecycle assessment (LCA) for emissions, also known as 'well-to-wake'. While SAFs still emit CO_2 during combustion, the CO_2 savings are generated earlier in the supply chain through the use of bio-feedstock. This approach faces criticism due to land use and potential competition with other uses, but there are no easy alternatives.

The lifecycle emissions from SAFs and their feedstocks vary widely, with different levels of regional acceptance. This means some SAFs offer significantly more carbon reduction potential compared to conventional jet fuel.

**This excludes the climate impact of non-CO_2 emissions (nitrogen emissions, particles, and water vapour) from jet fuel combustion at high altitudes, which is still under investigation but is estimated to be significant.*

Several variants in play, with BioSAFs covering the far majority

Previously, we explored the various production routes for variants of Sustainable Aviation Fuels, their economics, and the regional blending mandates and ambitious corporate goals driving their adoption. It's evident that a stronger supply is needed to meet these ambitions. BioSAF, and particularly those produced via the HEFA process, constitutes the majority of supply and offers the best economic proposition for short-term scaling.

All SAF types are expected to remain more expensive than conventional jet fuel. Conventional jet fuel typically accounts for 20-35% of total airline costs, which is significant in the low-margin aviation sector; someone has to bear the premium cost, which is a major challenge. The global and regional supply and demand dynamics of SAF are evolving, as is the thinking about how to navigate these changes and the actions of market players.

In this piece, we will focus on regional supply and demand developments for biogenic SAFs up to 2030, as well as the feedstocks behind these SAFs. What is the current dynamic, where are we heading, and what challenges do we face in pushing for widespread adoption? Synthetic SAFs will also start to play a role, but due to high costs, availability constraints for green hydrogen, and inefficiencies, we only expect significant uptake from 2030 onwards. We have examined the economics of synthetic SAF, and you can read about it here.

The world wants sustainability, so now comes the action

The global aviation authority ICAO aims to reduce emissions by 5% in 2030 through SAF blending. On the private side, IATA targets a 6% blend, while collectives like ‘Clean Skies for Tomorrow’ and ‘One World Group’ (including airlines such as American, Qantas, and Cathay Pacific) aim for 10% by 2030. Europe’s largest airline by passenger numbers, Ryanair, has committed to 12.5%. With an expected blend rate of just 0.5% in 2024, it’s clear there’s much work to be done in the next six years.

Governments worldwide have introduced blend mandates ranging from 1% by 2025 (Malaysia) to 10% by 2030 (UK) to encourage uptake. However, these efforts are fragmented, and targets alone are insufficient. Public (‘hard’) targets are more compelling, and shortfalls may lead to fines in countries like Germany.

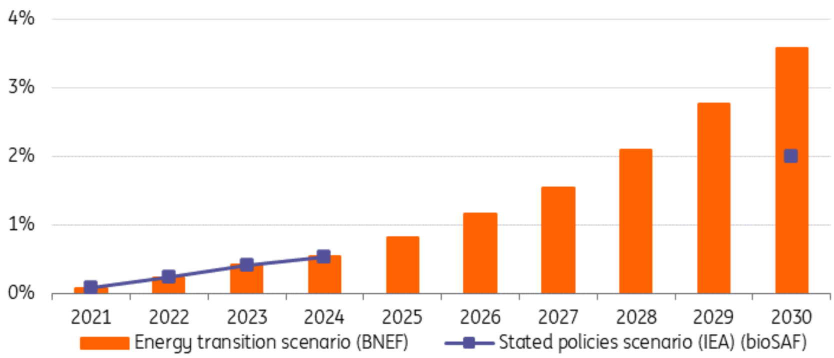
With SAF prices unlikely to match conventional jet fuel, more policy support is needed to turn aspirations into acceleration. Under current policies, the IEA expects bio-jet fuel to make up just 2% of global jet fuel consumption by 2030. In Europe, the emission trading scheme (ETS) helps create a more level playing field with conventional jet fuel, but additional measures are likely needed to achieve significant progress

Short term vs. long term SAF market

Airlines worldwide are beginning to blend SAF into their fuel supply. They can secure SAF supply by participating in investment initiatives, making long-term commitments, or relying on the spot market. Off-take agreements are a common method for ensuring future deliveries. These agreements also provide insight into future blend rates, demonstrating airlines' commitment to sustainable sourcing

SAF blending has started, but more support is needed to get beyond 2%

Expected blend rates* towards 2030 in two scenarios



Source: BNEF, IEA, ING Research *The BNEF-scenario includes a minor fraction of synthetic SAF

Expected global SAF blend rates far from stated goals

Global conventional jet fuel consumption is projected to rise to 6.6 million barrels per day (306 million tonnes) in 2024, with further increases expected in the coming years. The current small fraction of SAF is anticipated to grow to 3.5% by 2030 in an energy transition scenario (BNEF), assuming greater policy alignment. However, under the current stated policies scenario, the IEA expects this to reach only 2%. Both projections fall short of the targets set by the global aviation industry and individual airlines.

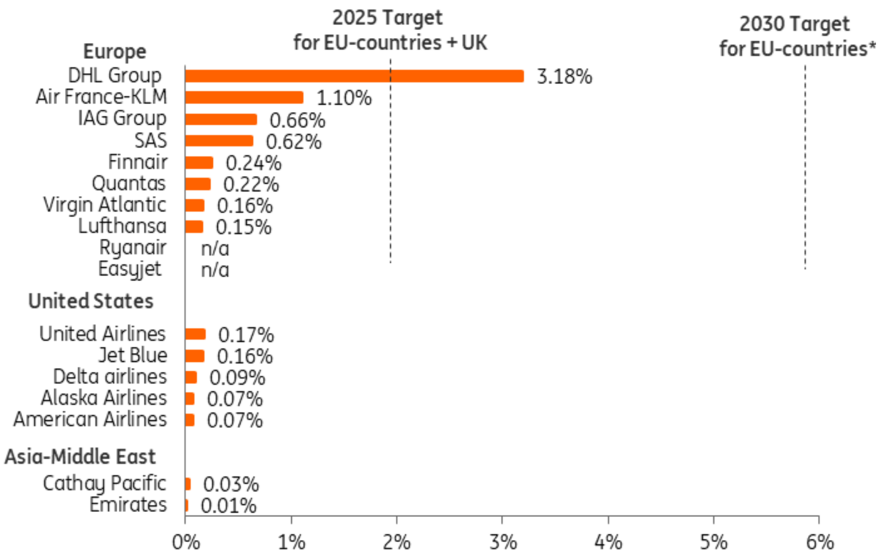
Airlines need to speed up SAF progress

European airlines are leading the way in SAF adoption, but there are significant differences among them. DHL Group, which operates freighters, is ahead, having successfully marketed SAF to B2B clients. Air France-KLM follows as a passenger airline, while other major European airlines like IAG (including British Airways) and Lufthansa began their SAF journey in 2023. However, many other airlines are just starting by preparing their supply chains.

In 2024, we expect to see progress in SAF blending, with Ryanair, for example, increasing SAF usage on specific routes in Europe. On the other hand, the overall climate strategy has faced setbacks due to various challenges. For instance, Air New Zealand has dropped its 2030 climate target.

European airlines ahead in SAF-blending, but still need to ramp up quickly

Ranking SAF Blend rates, airlines 2023, per region



Source: Bloomberg, ING Research

Three reasons why blend rates are not yet on track to meet targets

- Slower than expected realization of production facilities (particularly in Europe)
- Global airline traffic and jet fuel demand have massively rebounded, surging 20% in 2023 and 2024 combined. Volume eventually recovered faster than expected at the point of target setting. This means SAF volumes will need to progress even more.
- Airlines struggle to pass on the premium to private consumers on a voluntary basis. And the return of margin pressures also led to profit warnings in 2024. Required cost discipline could have a slowdown effect on short term blending efforts.

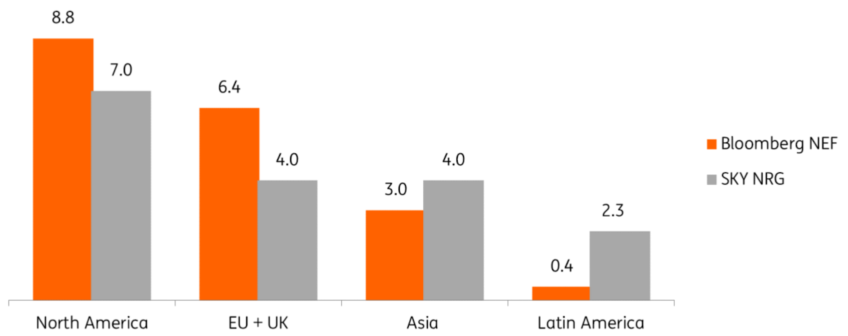
Europe and the US are expected to lead in SAF adoption, while Africa and Latin America lag behind. In the Asia-Pacific region, the world's largest and fastest-growing air traffic market, SAF blending is emerging. However, due to the high pace of expected growth and fragmented policy structures, increasing blend rates is expected to progress more slowly in the years leading up to 2030.

SAF will be sourced regionally, but Europe to remain reliant on imports

Sustainable Aviation Fuel (SAF) is expected to be sourced locally and initially supplied to relevant hubs. However, global trade flows will also play a role, involving either the feedstocks or the refined products. North America, Latin America, and Asia are anticipated to be exporters, while the EU market is expected to remain in deficit and continue importing feedstocks and SAF. Additionally, the eligibility of feedstocks varies by region and country, adding another layer of complexity to these trade flows.

North America expected to be the main producer of SAF by 2030

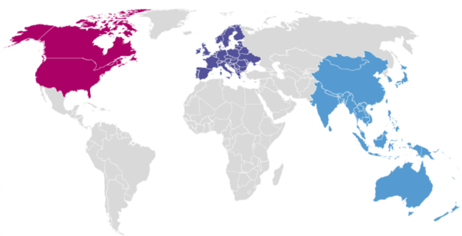
Forecasted production capacity in million tonnes of SAF



Source: Bloomberg, SKY NRG, ING Research

A regional flavour to the feedstock mix used for SAF production

Overview of some of the most relevant types of feedstock per region, including their reduction potential compared to emissions from conventional jet fuel



EU & UK**

Feedstock	Carbon reduction potential
Used Cooking Oil	High
Animal Fats	High
Municipal waste	High
Agricultural residues (like wheat straw and corn stover)	High
Intermediate and cover crops (like camelina)	High

North-America

Feedstock	Carbon reduction potential
Used Cooking Oil	High
Animal Fats	High
Municipal waste	High
Agricultural residues (like wheat straw and corn stover)	High
Agricultural feedstocks	
• soybean oil	Medium
• corn grain*	Low

APAC

Feedstock	Carbon reduction potential
Used Cooking Oil	High
Animal Fats	High
Municipal waste	High
Agricultural residues (like rice husks, straw, palm oil residues)	High
Agricultural feedstocks	
• sugarcane	Medium
• canola oil (Australia)	Medium
• palm oil	Low

Source: ICAO (CORSIA), ICCT, RSB, ING Research, *without CCS and climate smart-growing practices, ** Excluded: any SAF from food or feed crops (like palm oil / corn / sugarcane)

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The US has strong SAF potential, but it needs more policy support

The US is set to become the world's largest SAF producer

The potential for policy disruption following November's presidential elections is just one area of many to watch in the US SAF story

Supply-side incentives to make the US a major SAF producer

Unlike the EU and several APAC countries, the US does not have a medium-term sustainable aviation fuel (SAF) blending mandate to boost demand. Instead, the Biden administration has set an SAF production goal of 3bn gallons (9.1mn tonnes) per year, up from the 2024 production estimate of 0.46bn gallons (1.4mn tonnes). The growth of the US SAF market mainly relies on policy incentives from the supply side, and the country is poised to become the largest SAF producer in the world by 2030.

The most attractive policy incentive to realise the production goal is the Inflation Reduction Act (IRA), which provides tax credits ranging from $0.35 to $1.75 per gallon of qualifying SAF produced. These tax credits are playing a visible role in enhancing revenue streams and encouraging producers to supply more SAF into the market.

In addition to the IRA, state-level policy will play a crucial role in scaling up the SAF market from both the supply and the demand side. California has included SAF in its low-carbon fuel standard (LCFS) trading system, while Washington state has proposed to integrate SAF into its Clean Fuels Program. Washington, Minnesota, and Nebraska have established SAF tax credits ranging from

$0.75 to $1.5 per gallon of SAF produced, blended or both for about a decade.

SAF production incentives under the Inflation Reduction Act

Name	Section number	Credit amount (US$)	Timeline	Qualification	Additional guidance
Sustainable aviation fuel blending tax credits	40B	1.25-1.75/gallon	Valid until 31 Dec 2024	Qualified based on life-cycle emissions reduction (at least 50% of reduction potential, increased by 1 cent per percentage point of additional reduction)	• Use the new SAF40B-GREET emissions calculation model • Safe harbor for refiners to reduce an additional 10 gCO2e/MJ of carbon intensity using a full set of Climate Smart Agriculture technologies (CSA) for corns and an additional 5 gCO2e/MJ of carbon intensity using CSA technologies for soybeans. Corn CSA requirements for corn: No-till farming, planting cover crops, applying enhanced efficiency nitrogen fertilizer. CSA requirements for soybean: No-till farming, planting cover crops • Safe harbor for certain SAF producers to qualify using third-party verifiers accredited by the California Air Resources Board
Clean fuel (technology-neutral) production tax credits	45Z	0.2-1/gallon for non-aviation fuels 0.35-1/gallon for aviation fuels	Valid from 1 Jan 2025 to 31 Dec 2027	Qualified based on life-cycle carbon intensity	N/A

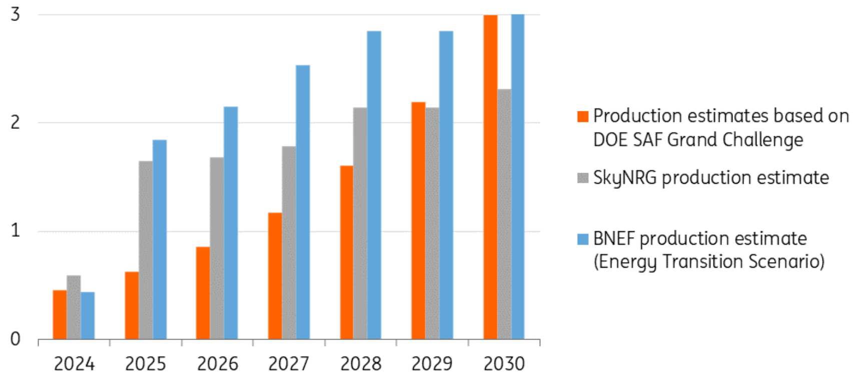
Source: ING research

Compared to other regions, notably the EU, SAF production in the US is expected to be predominantly based on agricultural feedstock, which includes soybean (Hydrotreated Esters and Fatty Acids, or HEFA, through soybean oil) and corn (HEFA through corn oil and Alcohol-to-Jet, or AtJ, through corn grain). Partly because of using agricultural products as feedstock and the associated existing infrastructure, SAF projects in the US are a lot larger in size. This, combined with the current financial incentives, is set to supercharge SAF production in the country.

According to Bloomberg New Energy Finance's Energy Transition Scenario (ETS), which is moderately more optimistic than business as usual, the US is capable of achieving the 3bn gallons (9.1mn tonne) grand production challenge target in 2030. Sky NRG is taking a more conservative view, projecting US SAF production of 2.3bn gallons (7mn tonnes) in the same year. More broadly in the Americas, South America is set to become an emerging supplier of SAF as well as SAF feedstock (from countries such as Brazil), although the region itself will not likely be a hotspot for SAF demand.

US SAF production estimated to pick up

Production forecasts from different sources, in bn gallons



Source: US Department of Energy, Bloomberg New Energy Finance, SkyNRG, ING Research

Will US production get there?

Whether the US can reach the 3bn gallons (9.1mn tonne) production challenge depends on feedstock availability, policy consistency, and offtake agreements.

Feedstock availability

SAF feedstock availability in the US can be affected by domestic agricultural output, processing of waste feedstocks, import, and competition from other fuels like renewable diesel.

First, agricultural feedstocks such as corn and soybeans can play a large role towards 2030 since they provide an opportunity to scale up SAF production quickly. Currently, they're at a disadvantage compared to waste feedstocks like used cooking oil (UCO) or animal fat because emissions from SAFs produced from agricultural crops are generally higher. This means that extra decarbonisation and efficiency measures are needed to receive tax credits. While policymakers have indicated that agricultural feedstocks can be a major part of SAF production, this will clearly have implications for land use (see also this paper).

Second, waste feedstocks such as used cooking oil, animal fat and municipal waste will be important. Regarding animal fats, the market for collecting and processing them into (aviation) fuels is already quite advanced. That's also the case for used cooking oil – although there seems to be some room to increase the available supply. For municipal waste, it's not about the supply, but about cracking the code to get facilities that process waste into fuel to a solid business model.

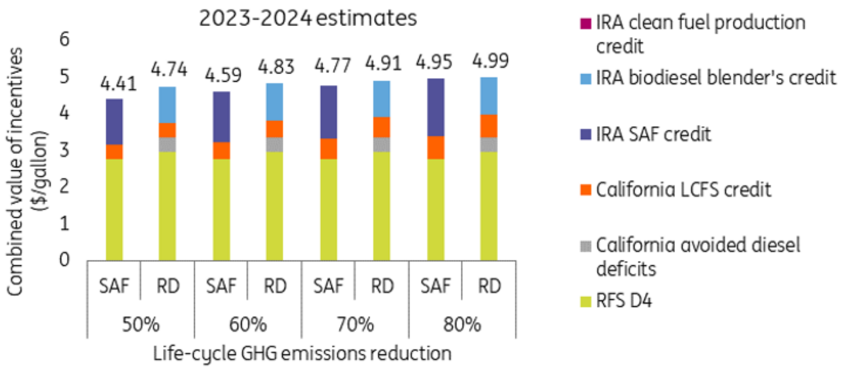
Third, imports of multiple types of feedstock into the US have gone up. US companies are increasing their imports of feedstocks from Asia (UCO) and Latin America (beef tallow from Brazil and soybean oil from Argentina). Such trade flows tend to be quite volatile because of the current nascent state of the market and because the demand side is heavily influenced by policy decisions. Looking ahead, political decisions like a tougher stance on China might affect UCO imports again in the future.

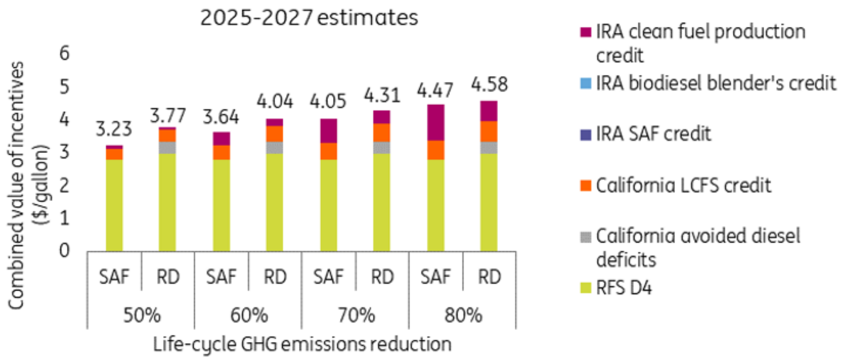
Fourth, SAF production in the US will continue to face strong competition from renewable diesel

(RD). Because of the similarity in production processes, feedstock, and infrastructure, a refiner can choose to produce renewable diesel or SAF, or both. In the short to medium term, policy support for RD is slightly more favourable than that for SAF, as indicated in the chart below. RD also has a more predictable demand growth path than SAF in the US. Nevertheless, in the long term, the production and demand for SAF can significantly build up since there are limited alternatives, and the demand for RD may soften because of electrification, which can incentivise more refiners to produce SAF.

Renewable diesel enjoys slightly higher policy incentives than SAF

Combined value of incentives in $/gallon





Source: National Renewable Energy Laboratory, ING Research

Policy consistency and innovation

Another factor that can disrupt both the demand and supply of SAF in the US is policy disruption after the elections. The Section 40B and Section 45Z tax credits under the IRA expire at the end of 2024 and 2027 respectively. If Trump is elected, these tax credits may not be scrapped right away, but may not be extended either. The aspirational production and demand targets set by Biden may be scrapped as well.

Policy stability is more guaranteed at the state level, but the current SAF policy design under the LCFS markets has not been effective. Take California as an example – SAF producers can boost revenue by selling SAF to the state's LCFS market (carrots), but the market itself does not have a limit on emissions from aviation (no sticks). Moreover, the surging demand for renewable diesel has led some refiners to choose to produce renewable diesel over SAF. As a result, SAF only accounts for 0.3% of the LCFS credits sold in California.

It is true that SAF demand will pick up this decade as airline companies, logistics companies, and even companies that have extensive travel emissions (such as consulting companies) work to achieve their sustainability targets. But what would take US SAF demand to the next level is blending mandates at state and federal levels, such as the Renewable Fuel Standards for road transportation.

Offtake agreements

Whether planned US SAF capacity can come online will also depend on project developers' ability to secure offtake agreements that are ideally long-term. In the US, the length of offtake agreements is low in general, with about 60% of the contract counts featuring purchasing commitments for five years or less. The longer and larger the offtake agreements are, the higher investor confidence tends to be, and the easier project financing might become. Demand-side policy needs to pick up for offtake agreements to be more easily penned.

The sustainability of SAF can affect trade and tax credit benefits

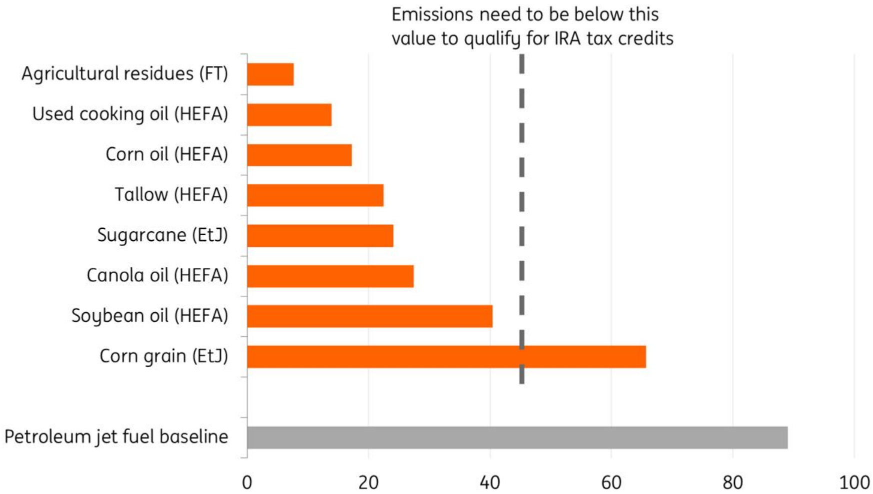
Despite these potential challenges, the US is still expected to see a surge in SAF production this decade, and it is highly likely that it will not be able to absorb it all. So naturally, US SAF producers will look to export their products. This would, in theory, be positive for the global SAF market – but in reality, the kind of SAF products the US can export to which regions will depend on feedstock.

The EU's Renewable Energy Directive, which lays out the criteria for a certain kind of energy to be considered 'renewable', excludes feed and food crop-based feedstock from SAF consideration. This means that US-produced SAF from corn, soybean, and sugar cane will not be able to be used to meet the EU's blending mandate for flights departing from the bloc. That would be a blow to future US SAF exports, leaving Asia as the principal remaining export destination; it could also create more supply-demand mismatches across different regions across the world.

Regardless of the EU's rule, for US-produced SAF to take advantage of the IRA's Section 40B tax credits, the life-cycle carbon intensity (CI) of an SAF needs to be at least 50% lower than those of traditional jet fuels, estimated at 89 carbon dioxide equivalent per megajoule, or g CO_2e/MJ (guidance for Section 45Z tax credits is expected to be released by the end of the Biden administration). And that is a problem for SAF production pathways such as corn-based AtJ, whose life-cycle carbon intensity is over 60 g CO_2e/MJ on average.

SAF life-cycle carbon intensity varies across feedstock types

Core life cycle assessment values, in grams of CO2 equivalent per megajoule of fuel, for a range of feedstocks compared to emissions from conventional jet fuel



Source: Chemical process, FT = Fischer Tropsch, HEFA = Hydroprocessed Esters and Fatty Acids, EtJ = ethanol-to-jet fuel, Research paper CORSIA: The first internationally adopted approach to calculate life-cycle GHG emissions for aviation fuels, ING Research

A recent policy development is the establishment of a safe harbour provision, which stipulates that corn and soybean-based SAF feedstock produced using all the required Climate Smart Agriculture (CSA) technologies can register an extra 10 g CO2e/MJ and 5 g CO2e/MJ of CI reduction respectively. This can potentially put corn and soybean-based SAFs in the range of 50% CI reduction, making them eligible for the IRA SAF tax credits. This guidance provides significant benefit for US SAF refiners as well as corn/soybean farmers while giving another boost to domestic SAF production.

Nevertheless, these CSA technologies are expensive to install, and the applicability can also depend on geography and soil. Finally, it is worth noting that these CI requirements are only applied to producers seeking for tax credits, but not mandatory for SAF production in general in the US (unlike the EU's rule). This means that while CI-conditioned tax credits are an important means to drive emissions reduction in SAF production, more policies may be needed in the long term. California has proposed a modification to the current LCFS to only allow companies to claim up to 20% of credits from biomass-based diesel produced from soybean or canola oil – and this may eventually be applied to SAF.

In short, the US is well positioned to become the largest SAF producer in the world, but whether all planned capacity can come online depends on policy support, feedstock availability, and offtake agreements. The life-cycle carbon intensity of SAFs will also determine how much of the fuel can be exported to jurisdictions with stricter rules, as well as how much federal incentive a refiner can get. Meanwhile, the US needs demand-side SAF policies to enhance consumer commitment.

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Europe leads the way on SAF, but airlines are struggling to hit targets

European airlines are leading the SAF charge

European airlines, such as Ryanair, are leading the SAF charge

European SAF demand needs to fly soon as regulation bites

European air passenger traffic accounts for 27% of global aviation, making it the second-largest aviation market after Asia-Pacific. In 2023, this translated to a jet fuel consumption of approximately 1.38 million barrels per day (65 million tonnes), a figure expected to rise as traffic volumes recover this year.

Europe is often viewed as a pioneer in climate policy and energy transition. The overarching 'Green Deal' and the 'Fit for 55' package are driving the aviation sector and its fuel suppliers towards greater sustainability. Here are the key policies within this framework:

- The Renewable Energy Directive (RED III) establishes a comprehensive framework for the energy supply sector, mandating that 42.5% of energy must come from renewable sources by 2030. For the transport sector, it sets a renewable energy target of 14%. Additionally, RED III outlines the eligible Sustainable Aviation Fuel (SAF) resources under the Refuel Aviation directive, specifically excluding food and feed crops as feedstocks.
- The ReFuel Aviation Directive mandates that all airlines use a 6% Sustainable Aviation Fuel (SAF) blend for flights departing from EU airports by 2030. Additionally, it requires aircraft to refuel at least 90% of the necessary volume to prevent tankering, which involves sourcing

fuel from other locations for return flights. The UK has set an even more ambitious target, aiming for a 10% SAF blend by 2030

Europe's ETS for aviation strengthens SAF business case

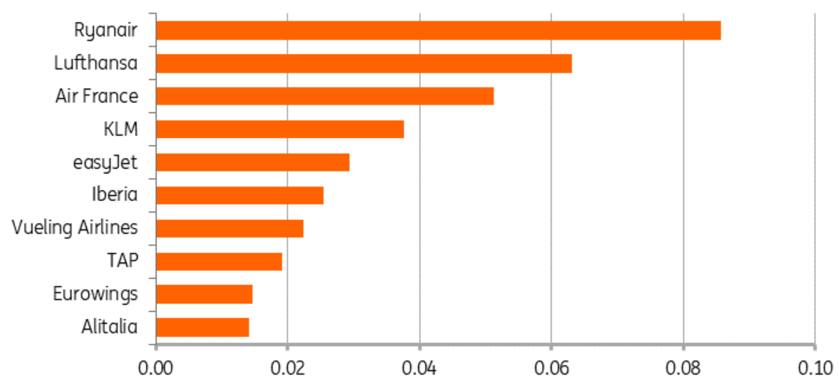
Intra-European flight traffic falls under the Emission Trading Scheme (ETS). As part of the 'Fit for 55' climate policy package, the free allowances for the aviation sector under the ETS are being gradually phased out. The system will be fully implemented by 2026, with a 75% reduction in free allowances in 2024 and a 50% reduction in 2025. Consequently, airlines will be fully accountable for their CO_2 emissions, which will increase fuel costs. The use of Sustainable Aviation Fuels (SAFs) reduces the number of credits airlines need to obtain under the ETS, thereby benefiting the SAF business case.

European blend rates exceed average, but 2% target still tough

According to data from BNEF and IATA, the blend rate in Europe is expected to reach just over 0.6% in 2024, falling short of the 2% target set by the ReFuel aviation directive for 2025. BNEF predicts that airlines may only achieve an average blend rate of around 1.25%. This shortfall could result in fines unless airlines purchase blend certificates. Additionally, airlines face challenges with governance clarity, particularly regarding bunkering outside of Europe and the use of SAF certificates to meet targets and avoid potential sanctions.

Ryanair is expected to be the largest SAF consumer in 2025 by volume

Top 10 European Airlines by expected SAF demand at European airports in 2025 (under the ReFuel aviation directive), in mn. tonnes



Source: BNEF

Offtake agreements help to get European SAF-supply going

European production of Sustainable Aviation Fuel (SAF) is expected to accelerate in the coming years, driven by offtake agreements secured by European airlines. Several agreements are in place to deliver SAF, including significant contracts between Air France-KLM and Neste (until 2030) and Total Energies (until 2035). DHL and Lufthansa have also disclosed offtake agreements.

To enhance future sourcing, substantial volumes have been agreed upon under Memorandums of Understanding (MOUs). Other suppliers in Europe include OMV and Shell. Additionally, IAG has secured the largest offtake agreement for synthetic SAF to date, covering the period from 2024 to 2039. However, the secured supply alone is insufficient to meet the 2025 requirements, necessitating reliance on the spot market and/or SAF certificates to fulfil the remaining demand.

Capacity set to meet demand despite delays and import reliance

If all planned capacity is realised as expected, there will be enough to meet the required demand and fulfil the 2030 mandate, according to SKY-NRG. However, past delays suggest that new capacity is rarely completed on schedule, meaning the scaling-up process may take longer than anticipated.

Earlier this year, we saw setbacks in capacity realisation. The construction of one of the largest Biodiesel/SAF facilities in Rotterdam was temporarily halted. Similarly, BP announced it would scale back its SAF production plans in Rotterdam, citing challenging market conditions with lower prices. This could impact offtake agreements and spot market supply. Short-term oversupply might be a factor, as more production capacity in the US and Asia comes online and flows to Europe. A sluggish phase leading up to the 2% obligation in 2025 could also contribute to this.

Despite these setbacks, new announcements continue to emerge, such as Neste's plans in Rotterdam. Complicating matters, refinery margins could shift due to competition with renewable diesel (HVO-100), as facilities can often switch output without significant cost. Given the global nature of the market, Europe will not be able to fully meet its own SAF demand and will need to rely on imports from North America or Asia, with this deficit expected to grow over time.

Feedstock and trade dynamics

The domestic supply of agricultural and waste feedstocks in Europe is quite limited compared to the mandated amount of SAF required by 2030. Additionally, EU criteria for qualifying feedstocks are generally stricter than those in North America or Asia, further reducing the potential supply pool. For animal fats and used cooking oil (UCO), collection and distribution networks in Europe are well-established, ensuring available resources are converted into biofuels.

However, there may be a shift from using these feedstocks in road transport to aviation. Unlocking additional feedstocks, such as cover and intermediate crops, holds some potential but requires developing and scaling up the necessary supply chains.

To meet its blending mandates, Europe will continue to rely on importing various feedstocks and SAFs. Historically, the EU has sourced feedstocks from the East, but some companies have also started establishing supply chains based on agricultural inputs from Africa. Trade flows have been turbulent over the past three years. For instance, UCO imports into the EU dropped by 30% in 2023 due to concerns about the authenticity of imports, particularly from China. However, data from the first half of 2024 show that UCO imports have been picking up again, indicating a strong business case for UCO.

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APAC sustainable aviation fuel demand set to trail behind supply

The APAC region has a fair amount of SAF projects in the pipeline, but less is happening on the demand side

Denpasar International Airport, Indonesia

More needs to be done to boost SAF demand

Looking at the demand outlook for sustainable aviation fuels in Asia Pacific is more difficult than it is in Europe. The outlook is going to largely depend on policy and, unlike the EU, there is no uniform policy for the region; governments in Asia have or will have differing approaches when it comes to decarbonising the aviation sector.

APAC makes up almost 32% of global air traffic and the region makes up more than a third of global jet fuel demand. Therefore, reducing emissions from the industry in the region is crucial, particularly given that air travel in the region is expected to show the highest growth rates through to 2030.

From a demand perspective, Asia is lagging behind initiatives in Europe, where ReFuelEU will mandate 6% SAF use by 2030. While more countries in Asia are setting SAF targets, there is a big difference from what we are seeing in Europe. Many governments are reluctant to put an SAF mandate in place. Instead, they have announced targets which are clearly a bit more flexible. Much will depend on SAF availability – and of course, cost. The region could benefit from a more coordinated approach when it comes to implementing mandates. In doing so, it would provide a more appealing environment for attracting the necessary investment on the supply side.

Looking at countries in the region that have announced mandates or targets – including China, which is expected to announce an SAF mandate imminently – SAF demand from these countries could total as much as 3-5.1m tonnes (1-1.7bn gallons) by 2030. This wide range is dependent on the target that China decides to go ahead with. However, this is a best-case scenario. In reality, actual SAF demand is likely to be lower for the region. BNEF forecasts APAC SAF demand to total around 2.3m tonnes (750m gallons) by 2030 under its ETS, while SkyNRG is assuming a demand number of around 2.5m tonnes (830m gallons) by 2030.

Looking at SAF offtake agreements in the region so far also suggests that demand will likely fall short of government targets. Volumes are still very modest and also generally short-term in nature. The only offtake agreement that stands out in the region is for 76m gallons at Kuala Lumpur International Airport in Malaysia starting in 2027.

APAC announced/planned SAF mandates or targets

Country	Annual jet fuel demand (m tonnes)	SAF target/ mandate	Explanation
China	37.2	No	Yet to announce a SAF mandate. However, it is widely expected to be announced soon with the expectation that it will range from 2-5% by 2030
Japan	11.1	Yes	Set a 10% blending mandate for SAF by 2030
Singapore	8.5	Yes	The government target is for 1% SAF from 2026, which will then increase to between 3-5% by 2030 depending on how the market develops and availability.
India	8.3	Yes	Targeting a SAF blend of 1% in 2027, 2% in 2028 and potentially 5% by 2030
Australia	7.5	No	There is no mandate in Australia. However, Qantas has set itself a 10% target by 2030, and is pushing for a SAF mandate.
South Korea	8.0	No	The government is expected to announce quality standards for SAF this year with the expectation that the government could introduce an SAF mandate in 2026.
Thailand	5.4	No	
Indonesia	3.9	No	The government wants to introduce a 5% SAF mandate from 2025.
Taiwan	3.3	Yes	The government has set an indicative target of 5% SAF use by 2030
Malaysia	3.2	Yes	Targeting a SAF blend of 1% by 2025.Longer-term the government is targeting a 47% mandate by 205.
Vietnam	2.1	No	
Philippines	2.0	No	
New Zealand	1.5	No	

Source: Press releases, EIA, ING Research

Note: 2019 jet fuel demand numbers used given demand is still recovering from Covid impact

Healthy but flexible pipeline of SAF projects

A big hurdle for much stronger SAF demand is adequate supply. This comes in the form of both production capacity and feedstock availability. However, Asia Pacific is seeing a large amount of investment in SAF capacity. Singapore is already home to the largest SAF facility in the world with the Neste plant, which has a capacity of 1.4m tonnes (460m gallons). It predominantly produces SAF, along with some smaller volumes of renewable diesel and bionaphtha.

By the end of 2024, the APAC region is estimated to have the ability to produce more than 1.8m tonnes (600m gallons) of SAF, equivalent to less than 1.5% of jet fuel consumption in the region. This capacity is expected to grow fairly quickly, with up to 1.8m tonnes (600m gallons) of additional capacity set to start up in 2025. Effectively, by 2030, the Asia region could have as much as 5.1m tonnes (1.7bn gallons) of SAF capacity if all projects go ahead – 4.2% of current jet fuel demand.

However, there is a large amount of flexibility in these numbers. Firstly, some of these projects could very well be cancelled. Shell, for instance, has already scrapped plans for a biofuel plant in Singapore. More recently in Australia, Oceania Biofuels ditched plans for a plant.

Projects that do not have long-term offtake contracts in place might also be reluctant or struggle to get the necessary financing to progress, given that it leaves them more vulnerable to spot prices, which have come under pressure more recently.

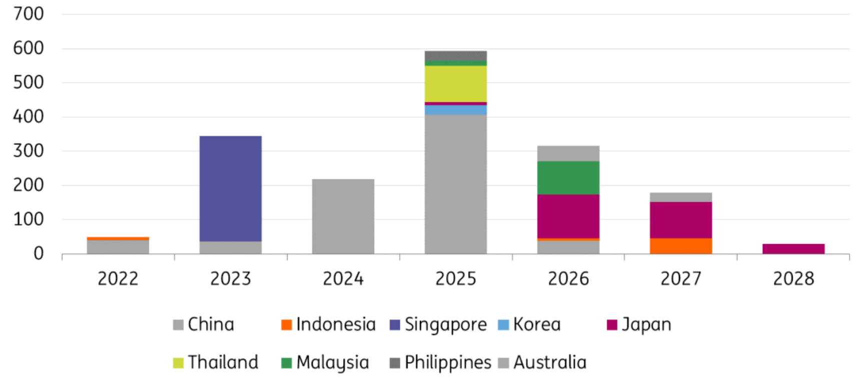
Secondly, given that SAF will not be the only product these plants produce, much will also depend on how dynamics in the renewable diesel market evolve.

Unsurprisingly, China has the largest amount of SAF capacity either under construction or planned, making up around 43% of total planned capacity in APAC by 2030. Singapore and Japan are a distant second and third, set to hold 18% and 16% of total regional capacity respectively.

Australia has only two projects in the pipeline that are estimated to be able to produce a little more than 200k tonnes (72m gallons) of SAF, although recently a third project was announced. These projects will use both Hydrotreated Esters and Fatty Acids (HEFA) and Alcohol-to-Jet (AtJ) technology. The estimated share of Australian capacity is fairly small, making up just 4% of expected APAC capacity. The lack of a mandate here is likely holding back further investment.

However, given that Australia is a large agricultural producer, there is potential for it to develop a SAF industry to take advantage of its feedstock supply. Otherwise, Australia could play a more important role as a supplier of feedstock to the region.

APAC SAF capacity in the pipeline (m gallons)



Source: BNEF, ING Research

SAF feedstock potential for the region

A key challenge for the market is feedstock availability, and this will obviously have ramifications on other sectors and/or regions as demand from the APAC SAF industry grows. Sectors and regions will have to compete more aggressively for feedstock.

The SAF technology being used and planned in the years ahead is largely HEFA. More than 70% of the planned capacity will use this technology. This points to a stronger demand for the likes of vegetable oil, animal fats and of course, used cooking oil (UCO). However, a recent joint study by the Roundtable on Sustainable Biomaterials and Boeing found that in Southeast Asia potentially other feedstocks are more abundant, such as rice husks. This suggests that in the longer term, the region will need to see investment in other SAF technologies, such as Fischer-Tropsch.

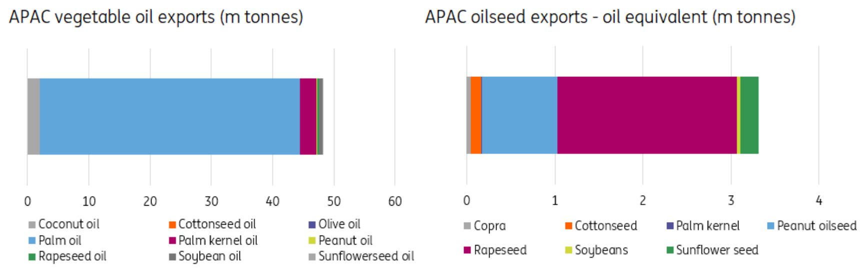
There is also potential for AtJ, with two of the three largest sugar producers in the world coming from Asia – India and Thailand – while China is also an important sugar producer.

For Asia, the HEFA production process makes sense for now given that there is already an abundance of vegetable oils in the region. The region is a dominant vegetable oil producer, largely driven by large volumes of palm oil from Indonesia and Malaysia. These two countries produce a combined 66m tonnes of palm oil, which is 85% of global supply. In addition, by-products such as palm oil mill effluent and palm oil residues can also be used as feedstock.

Australia is also a meaningful producer of rapeseed, which is relatively attractive when it comes to first-generation feedstocks given its oil content of around 40%, significantly higher than the 18-20% oil content of soybeans.

Australia makes up around 7% of global production but its exports make up more than a quarter of global export supply, leaving it the second largest exporter of rapeseed. Close to 80% of domestic rapeseed is exported, with a significant portion going to the EU. Over the past five years, the rapeseed crop has averaged around 5.6m tonnes, while exports have averaged around 4.4m tonnes. Clearly, the exportable surplus that Australia has could be diverted to a domestic biofuels industry if needed. Although, with Australia only having rapeseed crush capacity of around 1.2m tonnes, further investment in crush capacity would be needed.

APAC 2023/24 export supply of vegetable oil and oil seeds



Source: USDA, ING Research

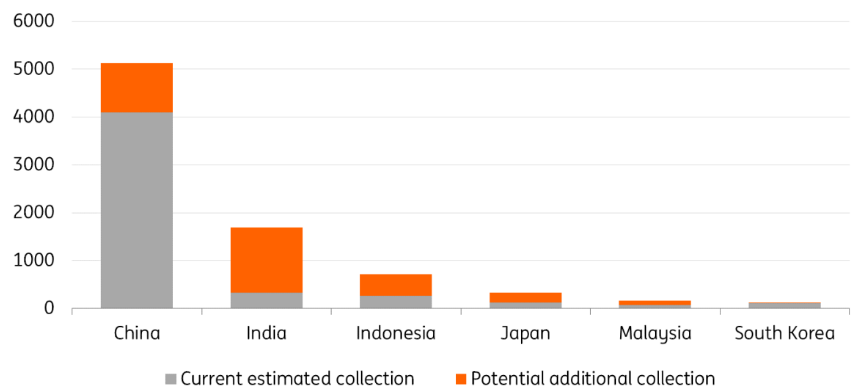
Increase in collection rates and use of other feedstocks required to ramp up SAF production

Looking at even more desirable feedstocks, the region is a large supplier of UCO, with China, Indonesia and Malaysia all amongst the top global exporters.

The bulk of planned SAF capacity in APAC will look to use UCO according to releases for the projects. The current and planned HEFA capacity in APAC is expected to be able to produce around 1.6bn gallons of SAF per year. This would require roughly 10m tonnes of feedstock. This is well above current collections of UCO in APAC, and so we would need to see an increase in collection rates along with the use of other feedstocks such as palm oil mill effluent, rapeseed oil and palm oil.

The International Council on Clean Transportation (ICCT) estimates that collection among the main UCO suppliers in Asia totals as much as 5m tonnes. An increase in collection rates could see this number grow to a little more than 8m tonnes, yielding potentially around 1.2bn gallons of SAF. This would mean that the need for SAF plants in Asia would also rely on palm oil and palm oil mill effluent. Heavy usage of palm oil would, of course, raise questions over how sustainable the fuel is. It would also not meet sustainability standards in some regions, like Europe.

Used cooking oil collections from key Asian suppliers (000 tonnes)

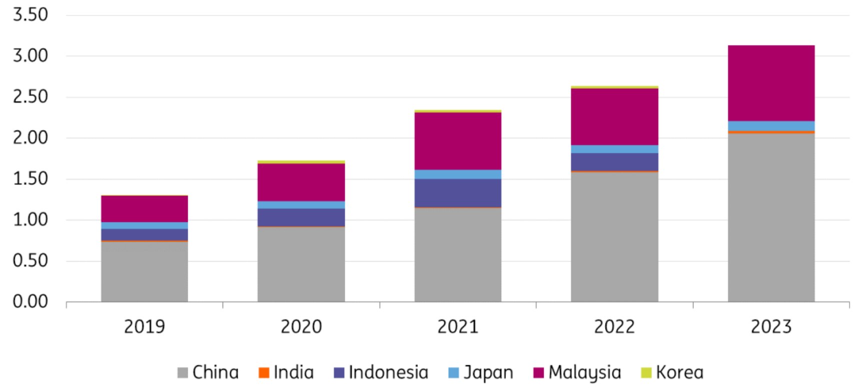


Source: ICCT, ING Research

Increasing SAF capacity will weigh on availability of feedstock for exports

Asia is already a key exporter of feedstock, with strong flows of UCO and rapeseed to Europe and the US. Naturally, as SAF capacity grows in the APAC region, this will weigh on the export availability of feedstocks unless we see a meaningful pick-up in collection rates of UCO and the use of alternative feedstocks in the region. This could create issues for SAF capacity in other regions when it comes to securing feedstock, given that Asia has been a growing supplier in recent years. In addition, given that APAC is expected to have a surplus of SAF capacity in the coming years, it also means that producers elsewhere will have to increasingly compete with SAF volumes from Asia.

Animal/vegetable fat and oil exports from key Asian suppliers (m tonnes)



Source: UN Comtrade, ING Research

Note: Used HS code 151800. 2023 trade data not available for Indonesia and Korea

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