SKYNRG

SUSTAINABLE AVIATION FUEL MARKET OUTLOOK

June 2024 Update

FOREWORD

"THIS YEAR WILL BE KEY FOR PROJECTS TARGETING OPERATIONS BEFORE 2030, AS MOST ANNOUNCED FACILITIES STILL FACE THE CHALLENGES OF RAISING CAPITAL, CONSTRUCTION, AND COMMISSIONING."

For over a decade SkyNRG has been recognized as a thought leader in sustainable aviation fuel (SAF), and this 4th edition of our annual SAF Market Outlook builds on that knowledge base. This report underscores the critical role of strategic investments and effective policy design in achieving net-zero aviation. Through the market analysis, it will help stakeholders looking get a deeper understanding of the evolving SAF industry.

We have expanded this year's edition beyond Europe and the United States. This Market Outlook incorporates SAF capacity announcements and policy developments worldwide. This shift highlights the increasing global commitment to sustainable aviation.

Over the past year, we have seen unprecedented growth in SAF capacity announcements, accompanied by a strong growth in sector investments. This includes Macquarie Asset Management's recent investment in SkyNRG, which will enable our next growth phase, aiming to realise SAF projects in both Europe and the United States.

Collaboration between project developers and investors is vital for success. However, stable policy frameworks are also required for the transition to net-zero aviation. The Market Outlook emphasizes the need for early policy discussions to evolve swiftly into concrete proposals to enable the building out of the significant pipeline of SAF capacity that we identify in this report. In addition, existing policies must offer long-term stability to attract and secure investor confidence. This is especially critical in the United States, where significant investments are ready to be deployed, contingent upon guaranteed long-term revenue certainty from supporting policies.

This year will be key for projects targeting operations before 2030, as most announced facilities still face the challenges of raising capital, construction, and commissioning. SkyNRG remains focused on working with sector partners and policymakers to enhance policy certainty and drive further investment into SAF.

The 2030 Market Outlook chapter was developed in collaboration with ICF and from the insights of many industry partners. We are grateful to all our partners for their invaluable support in compiling this report.

Philippe Lacamp
CEO, SkyNRG

EXECUTIVE SUMMARY

The global SAF market is at a turning point as most of the SAF consumed in 2025 will be under a mandate. Forecast production capacity reached 17.3 Mt (5.7 Bgal) by 2030, representing an increase of +4.0 Mt (1.3 Bgal) since this analysis was conducted last year. Regulatory developments are driving SAF demand, with mandates and aspirational targets adding up to a total demand of 16.1 Mt (5.3 Bgal) across multiple countries. Voluntary markets are expected to provide further demand signals. However, next year will be crucial for projects aiming to start operations before 2030. Most announced facilities still need to raise capital, build, and commission, making policy certainty essential to unlock the pipeline of SAF announcements.

On the 9th of October 2023, **ReFuelEU was formally adopted**, marking an important step towards completing the 'Fit for 55' package. Starting in 2025, EU jet fuel suppliers will have to supply a 2% SAF blend, initially averaged over the eligible EU airports they supply. This equals a demand of close to 1 Mt SAF (0.3 Bgal), which is double the global market in 2023.

Meanwhile, the **UK has published final details for a national SAF mandate**, which is confirmed to target 10% SAF by 2030. A forthcoming revenue certainty mechanism is anticipated to accelerate the development of domestic production capacity.

In the United States, long-awaited guidance on a federal blenders tax credit was published on 30 April. Fragmented incentives with short durations are expected to benefit projects that are already in construction, in production or projects with short payback times.

In the last year, several **other jurisdictions have further solidified SAF policies**. Notably, Japan, Singapore, India, Brazil, British Columbia, Indonesia and Malaysia have developed (proposals for) legislation to drive domestic SAF uptake. If all these policies materialize, this would bring the **global demand under targets to 9.2 Mt** (3.1 Bgal) and **under a mandate to 6.9 Mt** (2.3 Bgal) by 2030. Mandated demand could change significantly if major economies like China and the United States develop mandates.

Voluntary demand signals have continued to strengthen, with multiple airlines, cargo companies, and corporates setting ambitious SAF targets, amounting to some 12 Mt (4.0 Bgal) by 2030, including demand in regulatory markets. Voluntary purchases have been crucial to market growth over the past few years, but must translate into reliable, longer-term commitments in order to attract capacity above regulatory obligations.

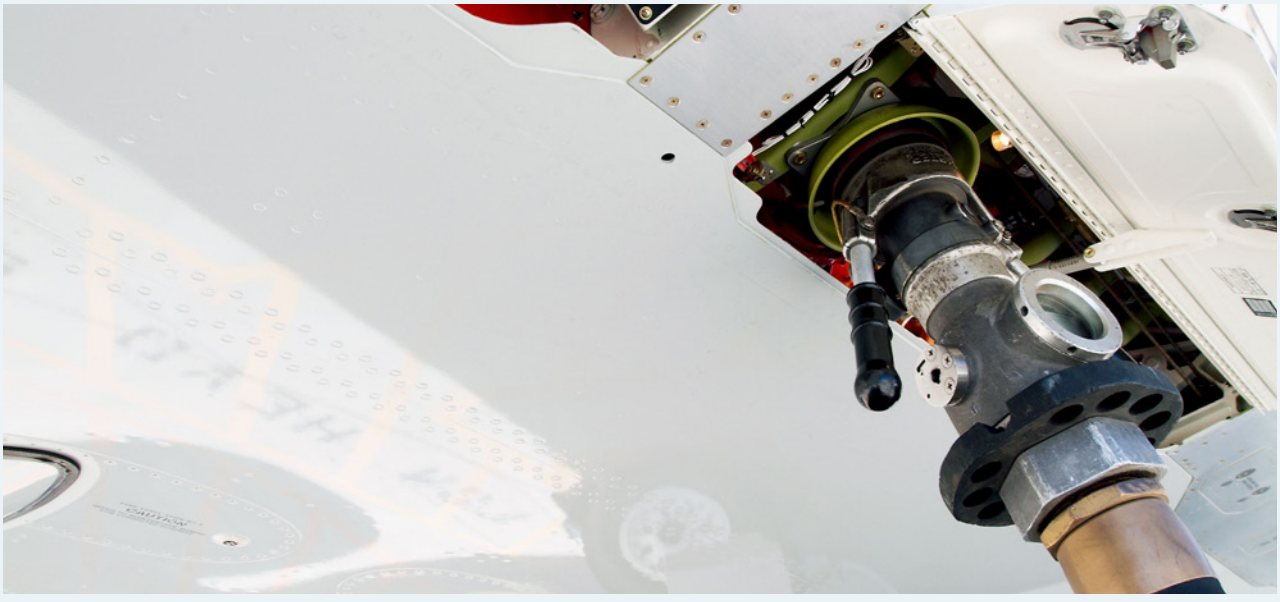
The **ICAO commitment to a Long-Term Aspirational Goal** (LTAG) of net zero by 2050, supported by the CAAF/3 target of 5% emissions reduction from SAF by 2030, provide valuable evidence of unity across the fragmented market. However, the most challenging steps are still to come, as countries develop tools to meet these targets.

SAF is increasingly becoming a globally tradeable commodity, with investments concentrating in countries with the most favourable policies. Regions that have historically been significant exporters of feedstock, such as China and Brazil, are now looking to move up the value chain and produce renewable fuels. **This move is giving rise to SAF trade corridors**, of which the SE Asia to Europe corridor is already operational today and a South America – US corridor could emerge as a significant second trade corridor by 2030, driven by fungibility of the SAF on the basis of feedstock.

Current global capacity announcements are dominated by the HEFA pathway, which represents ~85% of announced capacity in 2030. While co-processing makes up a smaller fraction of public announcements, we expect more projects to materialize given favorable economics and low complexity. Alcohol-to-Jet (AtJ) facility announcements have increased this technology to ~8% of announced 2030 capacity, supported by the commissioning of the first commercial-scale facility and clarifications to US federal tax credit greenhouse gas (GHG) methodology. All other technologies (including FT, e-SAF, and others) remain a minority of announced capacity, at ~7% of 2030 capacity.

EUROPEAN UNION

- Mandated SAF demand in the EU is expected to reach **2.8 Mt (0.9 Bgal) by 2030**.
- **Renewable fuel capacity announcements to date are expected[a] to deliver 3.8 Mt (1.3 Bgal) SAF by 2030**, with a total of 5.5 Mt (1.8 Bgal) in the pipeline. This suggests that a minimum success rate of ~50% would have to be achieved to meet EU demand when not factoring in imports. However, in 2024 we have identified an ongoing trend of delays in the sector, which means that actual SAF capacity in 2030 is likely to be lower than what has been announced.
- The **EU's e-SAF sub-mandate** will require 0.6 Mt (0.2 Bgal) of e-SAF by the 2030 – 2032 compliance period. Announced e-SAF projects to date are expected to deliver 0.3 Mt (0.1 Bgal) by 2030, with most projects – representing ~1.1Mt (0.4 Bgal) – **remaining in the feasibility stage**.
- Progressing just 20% of the announced e-SAF pipeline to FID could bring EU e-SAF capacity to the 0.6 Mt (0.2 Bgal) required for the sub-mandate.
- Until significant demand-side policies are in place outside Europe, **SAF is likely to be imported to the EU**. In the first years of the mandate, imports are expected to lead to a balanced supply situation. If this import situation persists, in combination with a high success rate of SAF capacity in the EU, more EU SAF volume could become available to the voluntary market, or some projects would optimize for HVO output.



[a] *Expected* announcements suggest that we have not included all capacity, such as those in feasibility stage. For the methodology, refer to the *2030 Outlook* section.

UNITED KINGDOM

- **Mandated demand is expected to reach 1.2 Mt (0.4 Bgal) by 2030**, depending on aviation demand projections.
- **UK SAF capacity announcements to date are expected to deliver 0.2 Mt (66 Mgal) SAF by 2030**, falling significantly short of the mandates. However, a total capacity of 0.6 Mt (0.2 Bgal) is in the pipeline and could be enabled through the announced UK revenue certainty mechanism.
- This relative gap between expected capacity and mandated demand is higher in the UK than the EU. We attribute this mainly to higher targets and a longer period of uncertainty on policy direction.
- The **HEFA-cap** under the UK mandate is expected to allow for around 0.9 Mt (0.3 Bgal) of HEFA-based SAF by 2030, with the rest coming from advanced fuels and e-SAF.
- Proposed **buy-out prices** set by the UK government are expected to lead to most of the targets being met with SAF supply instead of buy-out.

UNITED STATES & CANADA

- While the US has an **aspirational SAF target of 3 Bgal** (9.1 Mt) in 2030, this demand is not guaranteed. The likelihood of meeting these targets is dependent on availability of state and federal financial incentives, which are uncertain. While the federal Renewable Fuel Standard is continuous, the federal Blenders Tax Credit (40B) ends in 2024 and the anticipated Clean Fuel Production Credit (45Z) is currently only enacted from 2025 until 2027.
- **State-level SAF incentives** such as in Washington, Illinois, and Nebraska are expected to provide a better long term investment case to build up regional SAF production and use infrastructure.
- British Columbia marks the **first jurisdiction in North America to have passed a SAF mandate**, requiring aviation fuel suppliers to supply a 3% SAF blend by 2030.
- SAF capacity announcements to date in the US are expected to deliver **6.7 Mt (2.2 Bgal)** SAF by 2030, increasing to **7.0 Mt (2.3 Bgal)** if Canada is included. However, Canadian producers today do not have access to US federal tax incentives, putting them at a disadvantage to US producers.
- SAF facilities announced in the US are **significantly larger** compared to other regions, adding up to a total scale that exceeds waste and vegetable oil feedstock availability when combined with trends in the US HVO market.
- Already in 2023, capacity expansions in the SAF and HVO market led to the **US becoming a net importer of waste oil feedstock**.
- **Agricultural commodity feedstocks** like corn ethanol and soybean oil make up the predominant share of feedstocks for currently announced US SAF projects. Since SAF produced from food and feed crops is not considered eligible SAF in the EU and UK mandates, much of US SAF will not be eligible for export to Europe.
- US SAF capacity coming online is most likely to be used domestically for voluntary markets, while some could potentially be exported for compliance under the proposed Japanese SAF mandate. A smaller share of eligible SAF could be exported to the EU, benefiting from US production incentives from 2025 onwards.

REST OF WORLD

- Japan is emerging as a major potential demand centre for SAF outside of Europe, with 1.4 Mt (0.5 Bgal) required to meet the announced 10% mandate in 2030, followed by Brazil (- 3% GHG) and Singapore (0.3 Mt).
- SAF announcements are rapidly accelerating outside of Europe and North America, **especially in the Asia-Pacific region**. Sizeable facilities have come into operation with shorter lead times compared to Europe and the US.
- **South America** is also emerging as a significant production hub, utilizing its strong agricultural base. We identify a trend where, as in China and Southeast Asia, market players are **moving up the value chain** to capture more value in the renewable fuels markets.
- Based on current announcements, in 2030 we expect SAF capacity to be 1.4 Mt (0.4 Bgal) in **China**, 1.9 Mt (0.6 Bgal) in **Southeast Asia**, 0.1 Mt (33 Mgal) in **Japan**, 2.3 Mt (0.8 Bgal) in **LATAM**, 0.1 Mt (33 Mgal) in **Africa** and 0.2 Mt (66 Mgal) in the **Middle East**.

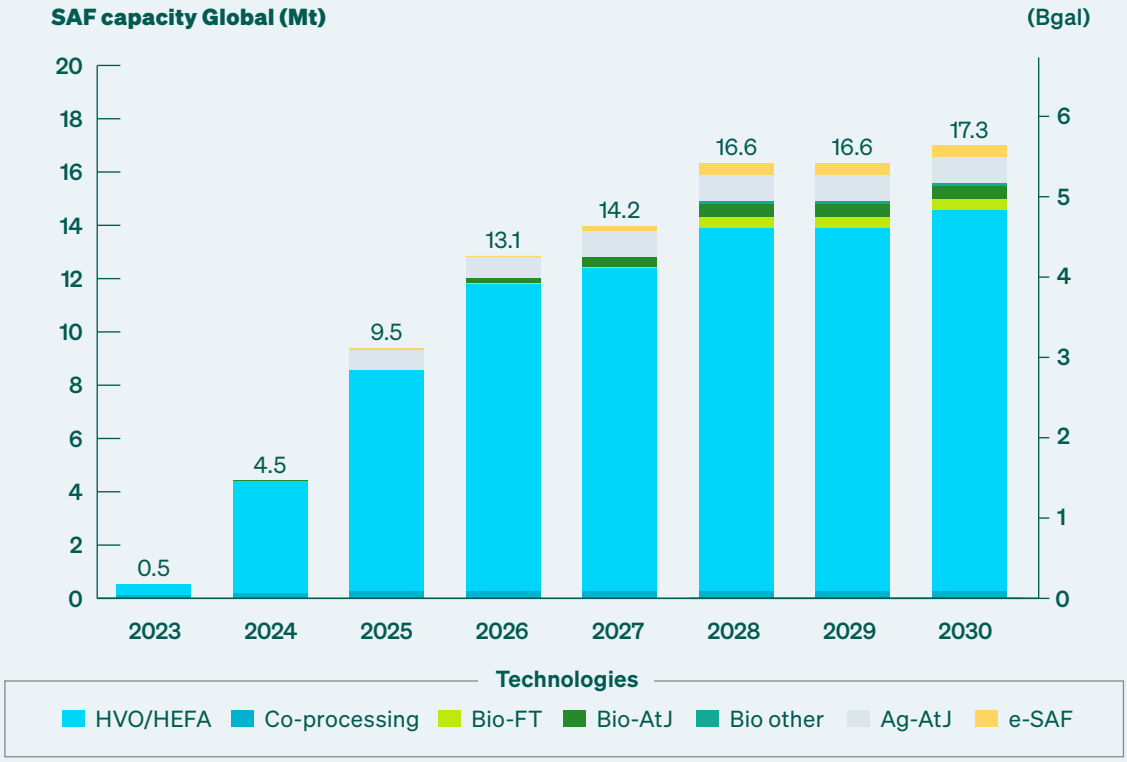


Figure 1: Global SAF capacity announcements until 2030.

INTRODUCTION

"TO DELIVER ON THE STEADILY GROWING PIPELINE OF SAF PROJECTS, 2024 NEEDS TO BE THE YEAR IN WHICH POLICY PROPOSALS ARE TRANSLATED INTO LONG-TERM REGULATORY FRAMEWORKS."

Aviation is responsible for 2–3% of global CO_2 emissions. After a dip in demand, passenger demand returned to pre-Covid levels for many regions in 2023.[1] By 2025, IATA expects passenger numbers to hit 4.6 billion and continue rising to 10 billion in 2050,[2] and if left unabated carbon emissions would rise in tandem.

Sustainable aviation fuel (SAF) is widely recognized as one of the major levers to minimize aviation's contribution to global CO_2 emissions. IATA expects that 65% of emission reductions required to reach net-zero by 2050 could come from SAF.[3] The recognition of SAF as a key instrument to aviation's transition has led governments to develop proposals to support the production and use of SAF, with the EU developing a long-term SAF mandate, and the US supporting production through a range of federal and state mechanisms.

This prospect of regulatory support and financial incentives from both the public and the private sector has led to a growing pipeline of SAF capacity set to come online before 2030. However, policy certainty and project success rates are inextricably linked. Many of the SAF projects that were announced over the last few years have faced delays and/or redesigns as they awaited final policy details. To deliver on the steadily growing pipeline of SAF projects, 2024 needs to be the year in which policy proposals are translated into long-term regulatory frameworks, bringing down project risks to acceptable levels for SAF offtakers and investors.

2030 SAF OUTLOOK

This chapter of the SAF Market Outlook was written in collaboration with ICF.

Momentum for SAF is at an all-time high, and press releases about SAF announcements, policy developments and airline offtakes are ubiquitous. In this chapter we bring it all together. Where do we stand on SAF policy, what can we expect from capacity announcements and what do both mean for where SAF will go in 2030?

Whether a facility makes it through a financial investment decision depends on many variables, not least having the right regulatory support. However, besides regulatory risk, there are other risk factors involved in projects that are embedded in the project design. This analysis therefore uses the following approach to arrive at expected SAF capacity by 2030:

- **Step 1: Identify renewable fuel announcements based on public information**
- **Step 2: Select projects that have a high probability of reaching production**
  This means we do not consider projects that:
  - → Are in feasibility stage
  - → Have not provided progress updates in 2+ years
  - → Are characterized with a high degree of compound risk (e.g. technology risk, feedstock risk, financial risk)
- **Step 3: Adjust SAF output, if needed**
  This means that we:
  - → Take public information at face value
  - → Adjust SAF announcements in case we have market intelligence that differs from the public information
  - → Apply average SAF yields based on the licensed technology.

The analysis focuses on SAF capacity. We incorporate the nameplate capacity of a facility in the year the facility becomes operational. This means we do not correct for the ramp-up period facilities require or for facilities that produce below their nameplate capacity.

SAF Demand: Policy Developments

European Union

With ReFuelEU formally adopted on the 9th of October 2023,[4] EU fuel suppliers are mandated to supply a 2% blend of SAF to EU airports, increasing to 6% in 2030. This drives mandated SAF demand in the EU equivalent to 2.8 Mt (0.9 Bgal) by 2030, based on demand projections supporting the regulation.[5] Other demand scenarios that assume a more aggressive growth are not included in this analysis.[6] A sub-mandate for e-SAF will require 0.6 Mt of the total volume to be e-SAF by the 2030 – 2032 compliance period. Final compromises to the mandate in 2023 have led to a wider range of feedstocks being eligible to count as SAF. Recycled carbon fuels can count towards the overall SAF mandate, as well as biomass waste feedstocks not on Annex IX, the latter of which is capped to 3% of total aviation fuel supply to EU airports.

Additional demand incentives are in place in the EU. Under its Emission Trading System (ETS), 20 million allowances are earmarked for the use of SAF on ETS-eligible flights between 2024 – 2030. This represents around EUR 1.7 billion of funding at current carbon prices. Advanced biofuels, e-SAF and SAF used at remote airports can count on higher levels of funding compared to waste oil-based SAF.[7]

United Kingdom

On the 30th of April 2024, the UK published the final details of the UK SAF mandate.[8] This will start in 2025 at 2% of jet fuel consumption, and rapidly increase to 10% by 2030. Government projections expect 1.2 Mt (0.4 Bgal) of SAF to be needed by 2030 to fulfil the mandate.[9] This projection seems to assume limited to zero growth in jet fuel demand.

The mandate caps the volume that can be met with HEFA-feedstocks, such as used cooking oils and waste tallows. Initially, the cap is not restrictive but falls to 71% of the total SAF supply in 2030, and plateaus in later years in volumetric terms. This represents around 0.9 Mt SAF (0.3 Bgal). The rest of the mandate will need to come from advanced biofuels, recycled carbon fuels and limited amounts of e-SAF. For e-SAF there is a sub-mandate in place starting in 2028 at 0.2%, increasing to 0.5% in 2030. A key difference to the EU mandate is a mechanism to adjust the contribution of SAF based on their carbon reduction, which will incentivise use of SAFs with a lower carbon intensity (CI), especially as negative CI technologies have been explicitly recognised in the latest consultation response.

United States

Although the US has an aspirational SAF production target of 3 Bgal (9.1 Mt) in 2030, demand in the US is not guaranteed. The likelihood of this 3 Bgal being uplifted in the US is dependent on the design of both state and federal incentives, and the strength of voluntary demand. While the federal Renewable Fuel Standard is continuous, the key federal incentive (known as the Clean Fuel Production Credit or § 45Z) is currently only applicable from 2025 until 2027. While its precursor (the Blenders Tax Credit or § 40B) has been renewed multiple times, this is not guaranteed to continue beyond 2024. This uncertain federal landscape has made state regulations critical, pioneered by the California Low Carbon Fuel Standard (LCFS). This has been followed by similar Clean Fuel Programs in Oregon and Washington, and SAF-specific production incentives in Washington, Illinois, and Nebraska. Voluntary markets are also expected to play a strong role in the US in coming years, since the stackable federal and state-level incentives can be combined with revenue from SAF certificates to close the price gap between SAF and conventional aviation fuel.

SAF demand in the US until 2030 is expected to be predominantly agricultural feedstock-based, leveraging the considerable US agricultural production. However, many of the supply and demand regulations reward lower-CI SAFs, which may drive a transition to lower emission feedstocks (such as waste oils and fats and other waste-based feedstocks) and the use of technologies such as carbon capture and sequestration.

Voluntary uptake of SAF under California's LCFS has only led to 8 Mgal (24 kt) of SAF use in 2021. While California passed a bill requiring the California Air Resources Board (CARB) to set a SAF usage target for aircraft in California of at least 20% by 2030, a path to implementation remains unclear. CARB has proposed updating the LCFS to cover fossil jet fuel used for intrastate flights, though when successful would require only 50 Mgal of SAF.[10]

Canada

British Columbia has passed SAF legislation requiring aviation fuel suppliers to supply a 3% SAF blend by 2030 in their overall aviation fuel supply. This represents a modest but mandated 17 Mgal (53 kt) of SAF by 2030.[11] Several federal programs are developing support for carbon capture and green hydrogen, which may indirectly support SAF producers.

Japan

Japan is emerging as a major potential demand centre for SAF. In 2023, the Japanese government published a policy proposal to develop a national SAF mandate requiring 10% SAF use by 2030. No details have been released on design aspects such as sustainability criteria and support mechanisms. A 10% SAF mandate by 2030 would represent a SAF demand of about 1.4 Mt (0.5 Bgal).[12]

India
India has communicated a policy proposal for a national SAF mandate of 1% by 2027, doubling to 2% by 2028 and potentially increasing to 5% by 2030.[13] A 2% mandate by 2028, which is most certain at this point, would require around 0.2 Mt (66 Mgal) SAF.

Singapore
Singapore has proposed a national SAF target of 1% by 2026, potentially increasing to 3–5% by 2030 depending on "global developments and the wider availability and adoption of SAF".[14] The Civil Aviation Authority of Singapore (CAAS) plans to introduce a SAF levy at a level sufficient to fund SAF at the applicable target level. A target of 3% by 2030 would represent about 0.3 Mt (0.1 Bgal) SAF.

Brazil
Brazil has advanced policy proposals that would enforce a 1% reduction in the average GHG intensity of jet fuel in Brazil by 2027, increasing year-on-year to 10% by 2037.[15] This means that by 2030, a 3% GHG intensity reduction would have to be realized, representing a minimum of 0.2 Mt (55 Mgal) SAF based on CORSIA default values for UCO SAF.

Malaysia
According to the National Energy Transition Roadmap published in 2023, Malaysia will establish a SAF blending mandate starting with 1% in 2025 and targeting a 47% SAF blending mandate by 2050,[16] although compliance has not been reported publicly. This represents some 40,000 tonnes (13 Mgal) of SAF.

Indonesia
Indonesia has in 2024 restated its ambition to introduce a 5% SAF mandate from 2025 onwards. However, Indonesian government is limited in its power to regulate SAF supply as it can only regulate airlines, not fuel producers.[17] A 5% SAF blend on all Indonesian aviation fuel demand would require around 0.4 Mt (0.1 Bgal) neat SAF.

Turkey
In 2022, Turkey came forward with a draft regulation for a SAF mandate. The mandate would start at 1% in 2025 and 2026, increasing to 5% SAF by 2030. If finalized, this mandate would require around 0.3 Mt (0.1 Bgal) SAF by 2030.[18]

United Arab Emirates
The UAE has in 2023 announced a 'guideline' that by 2031, 1% of the fuel supplied to UAE airports would be SAF produced from domestic SAF facilities by 2031.[19] This is a voluntary target and would represent some 70,000 tonnes (23 Mgal) of SAF. In earlier plans, the UAE government had announced an ambition to produce 700 million litres (0.6 Mt or 0.2 Bgal) of SAF per year by 2030. Regions with early discussions.

We further identify the following regions exploring SAF policy:

- **South Korea:** News are reporting South Korea may come forward with a proposal for a SAF mandate in 2024, with SAF mandates starting by 2026.[20]
- **China:** Already established a SAF use goal of 50,000 tonnes. Industry seems to be expecting a blending mandate of 2 – 5% by 2030 to be announced. A 5% mandate would require 2.5 million tonnes of SAF use in China by 2030.[21]
- **Australia and New Zealand:** Early coalition work is ongoing under the name of SAFAANZ to conduct sector consultation, supported by allocations for further assessment and investments in the most recent Australian budget.

SAF Supply: Capacity Announcements

European Union

SAF capacity announcements to date are expected[b] to deliver **3.8 Mt (1.3 Bgal) SAF by 2030**, with a total of 5.5 Mt (1.8 Bgal) in the pipeline. This suggests that a minimum success rate of 50% would have to be achieved to meet EU demand. Today, only about 1.8 Mt (0.6 Bgal) of this pipeline is operational or under construction. Besides EU-based production, we also expect SAF to be imported to the EU for compliance with ReFuelEU. In the short term, this is expected to lead to a balanced supply situation as EU capacity is ramping up. However, if this import situation persists, in combination with a high success rate of SAF capacity in the EU, SAF projects are expected to optimize operations to yield HVO instead of SAF. Another route forward for EU projects could be to supply for the voluntary market.

There is little publicly available information about petroleum refiners planning to use co-processing of renewable feedstock to produce SAF, even though a significant share of the SAF used today is produced via co-processing. Since this pathway represents low capital investments relative to other SAF pathways, co-processing represents a cost-effective compliance method under ReFuelEU. If EU refiners were to fully utilize their co-processing capacity to the ASTM limit of 5%, this could yield around 1.7 Mt (0.6 Bgal) SAF per year. With recently amended eligible feedstocks under the Renewable Energy Directive, refiners will have more feedstock flexibility for this pathway which will include biomass-based oils produced from intermediate crops, also known as cover crops.

Announced e-SAF projects to date are expected to deliver 0.3 Mt (0.1 Bgal) by 2030, with most projects remaining in the feasibility stage. However, the total pipeline of e-SAF projects is 1.2 Mt (0.4 Bgal). This means that progressing just 20% of the announced e-SAF pipeline to FID could bring EU e-SAF capacity to the 0.6 Mt (0.2 Bgal) required for the sub-mandate.

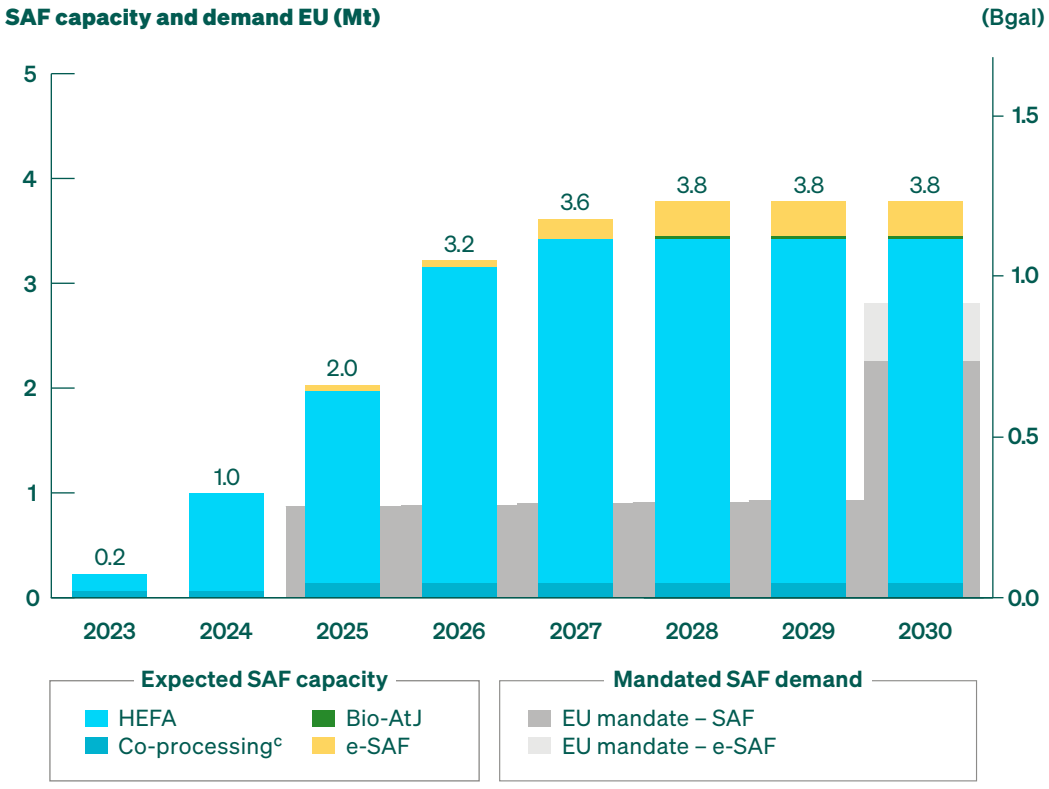


Figure 2: Expected SAF capacity in the EU27 and UK by 2030, based on 2024 announcements.

[b] *Expected* announcements suggest that we have not included all capacity, such as those in feasibility stage. For the methodology, refer to the *2030 Outlook* section.
[c] For co-processing we use an actual production volume instead of a total production capacity.

United Kingdom

SAF capacity announcements in the UK are currently expected to deliver **0.2 Mt** (0.07 Bgal) **SAF by 2030**, falling meaningfully short of the mandate. This relative gap between expected capacity and mandated demand is higher in the UK than the EU. We attribute this mainly to higher SAF targets, the cap on HEFA use, and a longer period of uncertainty on policy direction. However, the recent announcement of the final details of the UK mandate should provide confidence to UK projects. The HEFA cap has led UK-based producers to focus on more sustainable feedstocks such as municipal solid waste, industrial waste gases and cellulosic ethanol. Although direct government funding was provided through the Advanced Fuels Fund (AFF), the combination of technology risk and policy uncertainty has held back any of these projects from starting construction at the time of writing. The mandate details could allow some of these projects to progress, and the potential revenue certainty mechanism would further accelerate the industry. The total announced capacity in the UK is currently 0.6 Mt (0.2 Bgal), so even if all these projects succeed, there is still room in the market for additional UK-based projects and imports.

If we compare the results of all SAF projected announcements from the same analysis over the past years (see Figure 4), there is an ongoing trend of delays in the sector. We attribute this to delays that have accumulated due to policy uncertainty before ReFuelEU and the UK mandate were final, as well as inflationary pressures that have forced projects across the entire energy industry to redesign. Today, a significant increase in SAF capacity is expected to take place in the next two years. This can only materialize if multiple SAF facilities take FID this year and are able to limit construction and commissioning to two years.

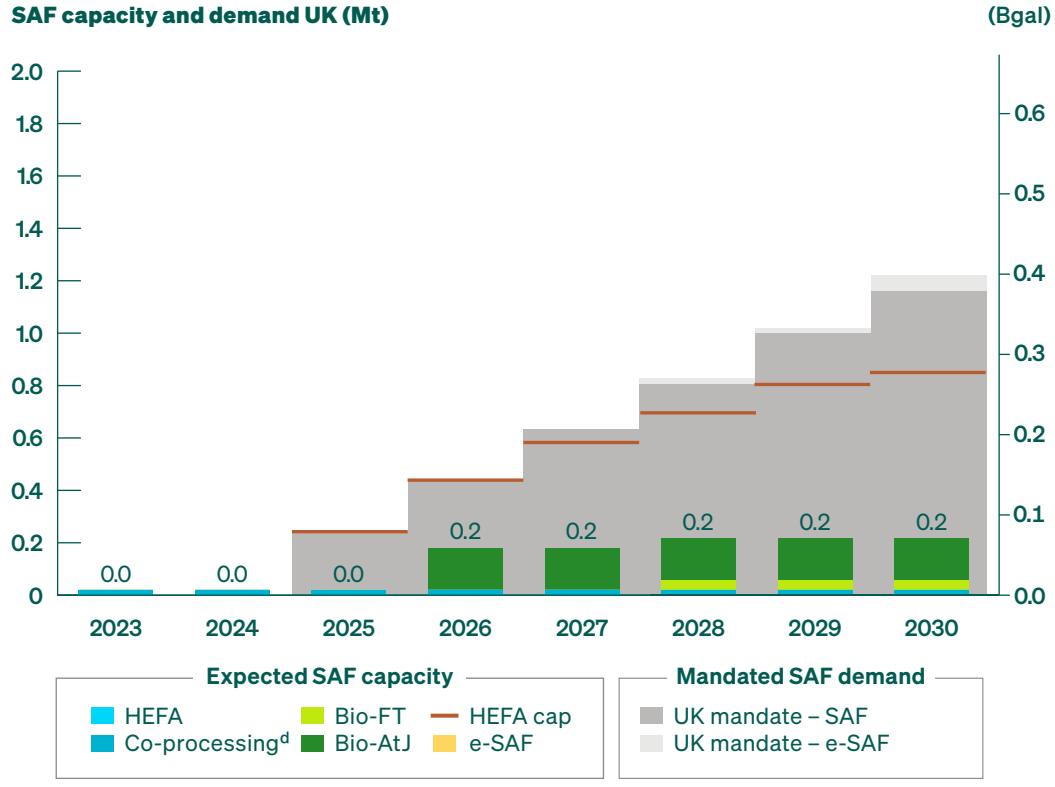


Figure 3: Expected SAF capacity in the United Kingdom until 2030, based on 2024 announcements.

[d] For co-processing we use an actual production volume instead of a total production capacity when an actual production volume is communicated.

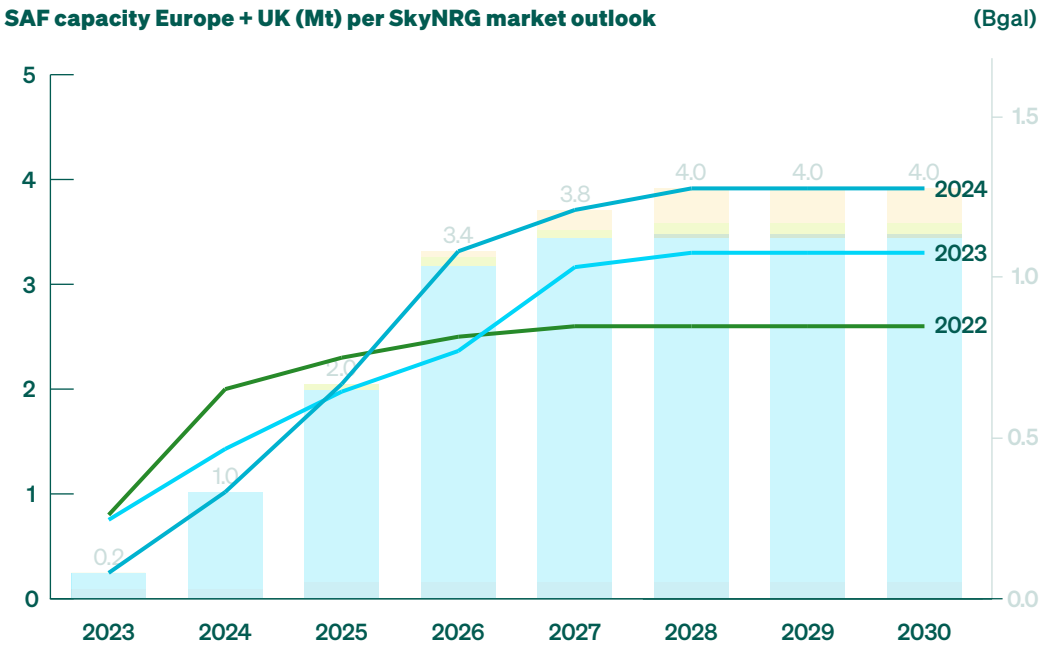


Figure 4: Expected SAF capacity in Europe and UK for the past three editions of the SkyNRG Market Outlook, based on announcements.

United States & Canada

SAF capacity announcements to date in the US are expected to deliver 6.7 Mt (2.2 Bgal) SAF by 2030, though including Canada the total is **7.0 Mt (2.3 Bgal)**. However, Canadian producers today do not have access to some of the US SAF incentives and the mandate in British Columbia is too small of a captive market to support Canadian projects, putting them at a disadvantage to US producers. While guidance for the § 40B tax incentive until the end of 2024 is now final, further guidance will come out for the 2025–2027 period for the CFPC (§ 45Z). Continued uncertainty on tax guidance pertaining to GHG methodologies and incentive levels, in combination with increasing pressure on feedstock markets is expected to lead to further delays in SAF capacity expansion across the US. At the time of writing, only 2.1 Mt (0.7 Bgal) of SAF capacity is covered by facilities that are operational or under construction.

SAF facilities announced in the US are significantly larger compared to other regions. Capacity announcements exceeding 300 Mgal (0.9 Mt) are not uncommon, whereas these are the exception in the rest of the world. We attribute this to feedstock strategies chosen in these projects, which are mostly agricultural commodity-based, and the existing feedstock and logistics infrastructure. Indeed, agricultural feedstocks like corn and soy make up the predominant share of feedstocks for currently announced US SAF projects, which cannot be exported to Europe aside from the share of SAF produced from RED II-eligible feedstock. We expect US SAF capacity coming online by 2030 to be mostly used for the voluntary market, with some potentially exported for compliance under the Japanese SAF mandate.

US SAF announcements using the HEFA pathway are currently totalling 5.1 Mt (1.7 Bgal) by 2030. This feedstock demand is adding up to a total scale that exceeds waste and vegoil feedstock availability when combined with announcements in the US HVO market, which will demand this same feedstock. Already in 2023, these trends led to the US becoming a net importer of waste oil feedstock.[22]

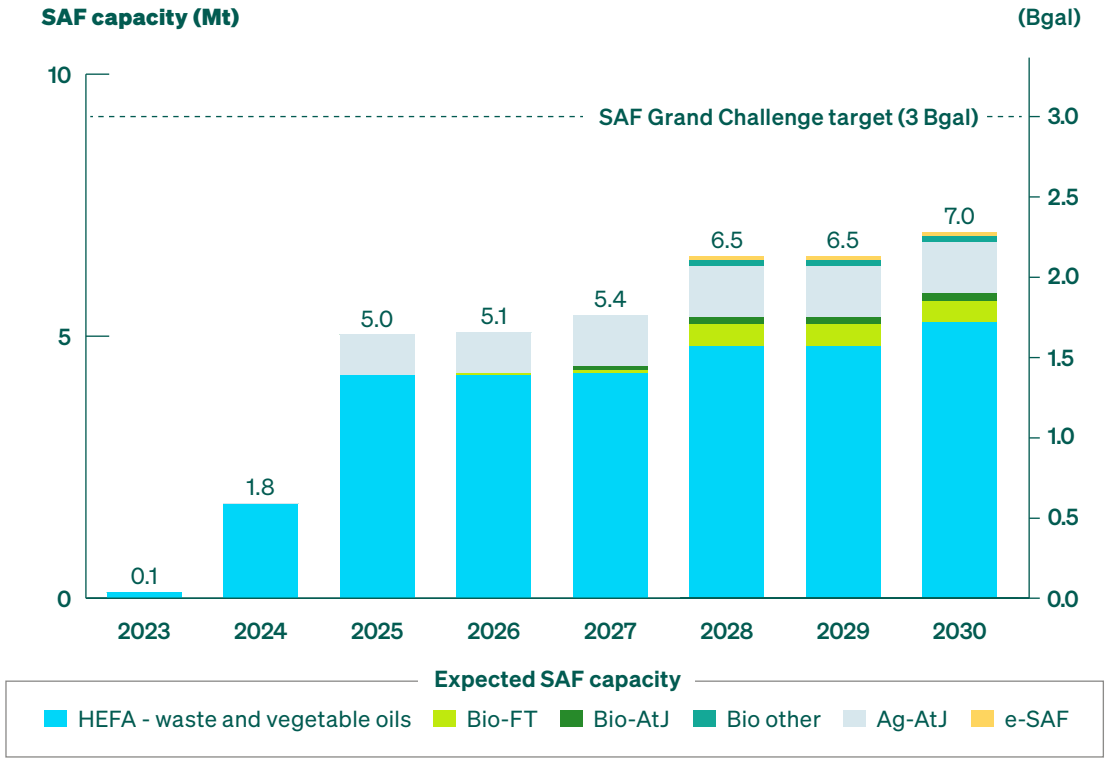


Figure 5: Expected SAF capacity in the United States and Canada until 2030, based on 2024 announcements.

China & Southeast Asia

SAF capacity is rapidly expanding in China, with lead times that are seemingly shorter than in the rest of the world. Several Chinese SAF facilities are operational as of 2024, and Neste's Singapore refinery is expected to be fully operational this year. The majority of this announced capacity would be eligible under ReFuelEU and some of it is already exported to Europe. Based on current announcements, we expect China and Southeast Asia to have a SAF capacity of 3.6 Mt (1.2 Bgal) by 2030.

LATAM

Latin America is emerging as a potentially significant production hub for SAF, with an expected SAF capacity of 2.3 Mt (0.8 Bgal) by 2030. Already today, Latin America is a major exporter of agricultural commodities and countries such as Brazil and Argentina have historically demonstrated their ability to capture more value up the value chain by exporting the green molecules instead, e.g. in the case of biodiesel and bioethanol. Some US SAF projects are intending to make use of Brazilian ethanol (particularly as Brazilian sugarcane ethanol can achieve lower carbon Intensities than US corn), signalling that in the future the US may be importing finished fuel.

Rest of World

Africa is currently underrepresented in global capacity announcements, expected at 0.1 Mt (33 Mgal) SAF by 2030, concentrated in Egypt and South Africa. Other noteworthy developments include Australia (0.4 Mt SAF, 0.1 Bgal).

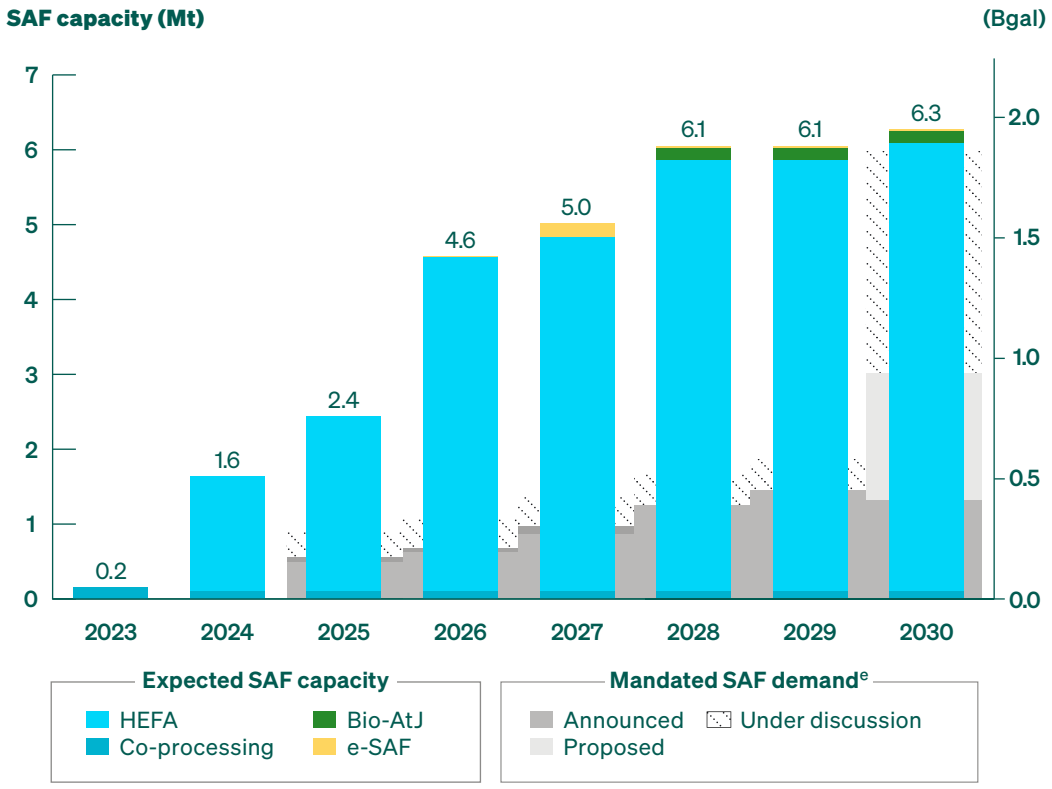


Figure 6: Expected SAF capacity in South America, Middle East and Asia Pacific until 2030, based on 2024 announcements.[e]

[e] Announced includes Singapore, Malaysia, Indonesia, China (50 kt), India, Brazil; Proposed: Japan, Turkey. Under discussion: China (5% mandate 2030), South Korea.

Global SAF Corridors

SAF is typically used in the markets where it delivers the highest value. This is usually a function of market price, available incentives and cost of transportation and blending. However, value can also be assessed on the basis of avoided cost. The non-compliance penalty system used in the EU or the buy-out prices proposed in the UK are both tools to ensure that SAF blending targets are met and will cause eligible SAF from around the world to flow towards these compliance markets if they are threatened to be undersupplied.

When stacking up SAF demand from implemented and announced policies against SAF capacity announcements, surpluses and deficits start to emerge. Based on sustainability criteria and cost of supply we can estimate how these surpluses and deficits are most likely to be balanced out.

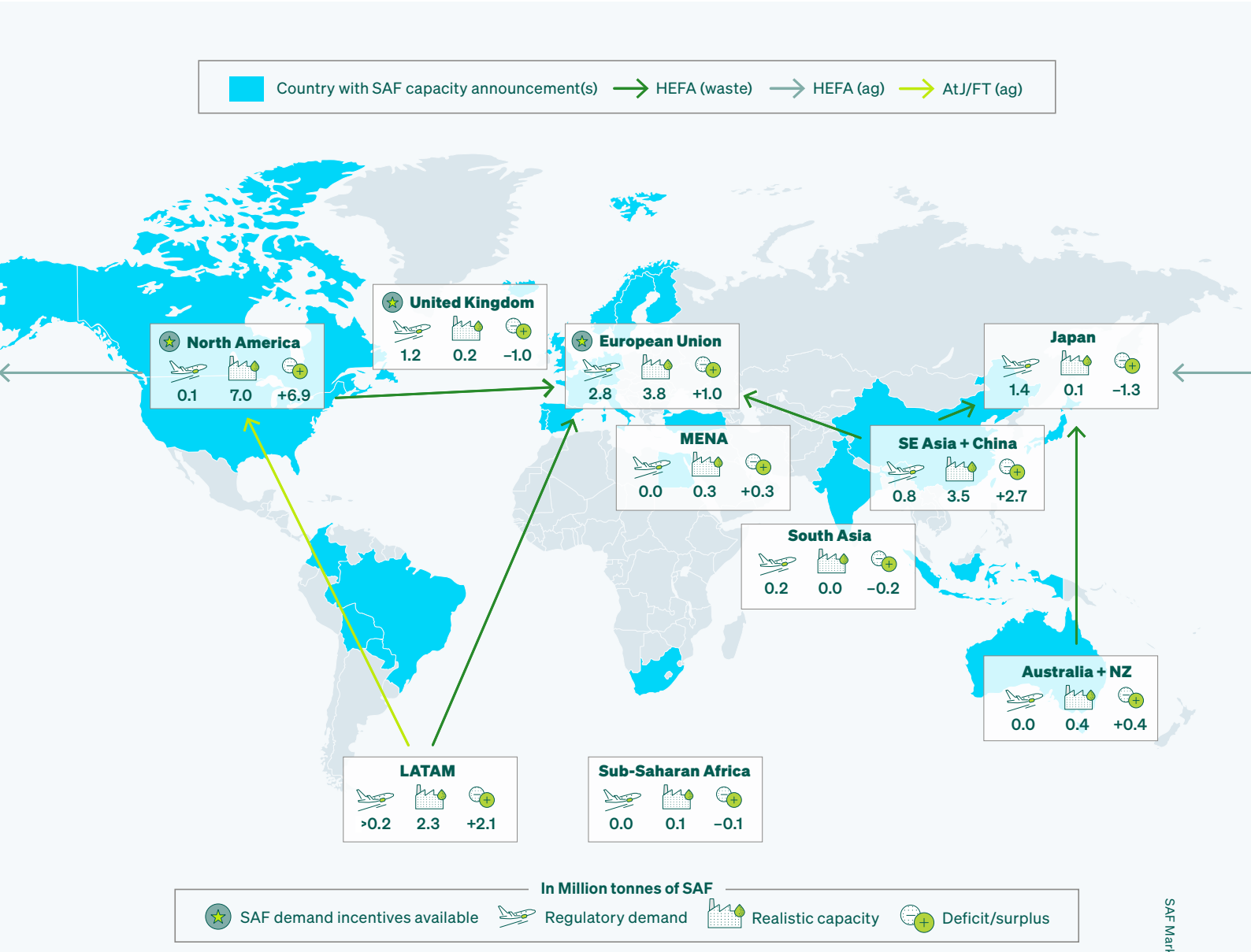


Figure 7: Overview of expected global SAF dynamics by 2030 based on SAF demand, SAF announcements and SAF policies implemented and announced.

Based on policies implemented and announced today, the dominant 'pulling' forces by 2030 are expected to be:

United States: With the availability of RINs, federal tax incentives and several state low-carbon fuel standards in place and under discussion, blending eligible SAF in the US is relatively attractive. The transition from federal blending credits to production credits in 2025 may favour domestic production, perhaps complemented by SAF imported from:

- **LATAM**: There is a match on feedstock and pre-existing trade relationships on agricultural commodities.

European Union: Being the largest mandated SAF market and having a strong non-compliance mechanism in place, SAF is likely to come from:

- **China and Southeast Asia**: Imports already come into the EU. The trend of shifting from importing feedstock to importing renewable hydrocarbons is expected to continue.
- **United States**: EU-eligible, waste-based SAF could be imported into the EU. Production tax incentive could make US-based fuel more competitive if the EU does not come with counter measures.
- **LATAM**: EU-eligible, waste-based SAF or SAF produced from intermediate crops could be imported.

Japan: High SAF targets have been announced and sustainability criteria are expected to be relaxed towards the use of agricultural feedstock. SAF is likely to come from:

- **China and Southeast Asia**: Palm residues may be allocated to Japanese markets over lower concerns compared to EU players.
- **Australia**: Australia is experiencing increased investment from Japanese firms aiming to secure feedstock and SAF supply.[23]
- United States: Ag-based SAF (soybean) may be exported to Japan.

There are several scenarios that could significantly alter Figure 6.

1. **Protectionist policies in the EU and/or UK putting in place import duties for imported renewable products**, meaning a stronger role for domestic facilities to fulfil the mandate. This could be catalysed if the switch in the US from the federal blending credits to production credits (BTC to CFPC in 2025) reduces US domestic demand and allows subsidised US production to flood foreign markets. The EU and UK policies, and US state policies, overlaid by voluntary demand, complicate this outlook.

2. **Increased SAF demand from China, South Korea, and Singapore**. This could reduce both the exports of SAF and feedstock, which is currently going to Europe and the United States. The potential implementation of a Chinese SAF mandate has been mentioned via several sources and could be anywhere between 2 and 5% by 2030. If the Chinese government opts for a 5% mandate, equal to 2.5 Mt SAF, this would have major implications for the global SAF market. For the EU in particular, this could amplify the urgency to transition to non-HEFA pathways to meet targets under ReFuelEU.

3. **Ramp up of ambition in the maritime sector, and renewed demand on-road**, potentially steering some SAF capacity to optimize for renewable diesel. The expansion of the EU Emission Trading System to cover some maritime traffic may start this process, and higher on-road demand could be catalysed if progress on EVs slows, perhaps combined by greater energy security and environmental factors driving the need to diversify from fossil fuels.

2050 SAF OUTLOOK

For the global aviation industry to reach net zero by 2050, IATA estimates that roughly 360 Mt of SAF will be required.[24] This volume depends on the growth of aviation demand over the next three decades, as well as the development of other pieces of the decarbonization puzzle – hydrogen and electric planes, operational and infrastructural improvements, and offsets.

In our analysis, we constrain SAF growth by the maximum pace of deployment[f] and feedstock availability for each of the pathways. We estimate that global SAF capacity could grow to ~250 Mt by 2050, if deployment of new pathways using biomass feedstocks and green hydrogen are derisked over the coming years and accelerate rapidly thereafter. In addition, it requires rapid mobilization of new feedstock supply chains: in particular the use of cover crops and perennial crops to enable growth in the HEFA pathway and utilization of municipal solid waste, agricultural and forestry residues for Alcohol-to-Jet (AtJ) and Gasification + Fischer Tropsch (G+FT).

Feedstock Availability

In our analysis, we focus on three feedstock streams: waste/low-ILUC oils and fats for the HEFA pathway, cellulosic materials and MSW for the biomass pathways (AtJ and G+FT), and green hydrogen for the e-SAF pathway. SAF feedstock availability is dependent on the total availability of these feedstocks, the claim aviation can make on these feedstocks and the SAF yield from these feedstocks. We use public data to estimate the global availability of these feedstocks from 2030 to 2050, see Figure 8. HEFA availability is based on public commentary by ENI and Neste[25], green hydrogen availability on publications by the Hydrogen Council and McKinsey[26], biomass potential based on IEA.[27]

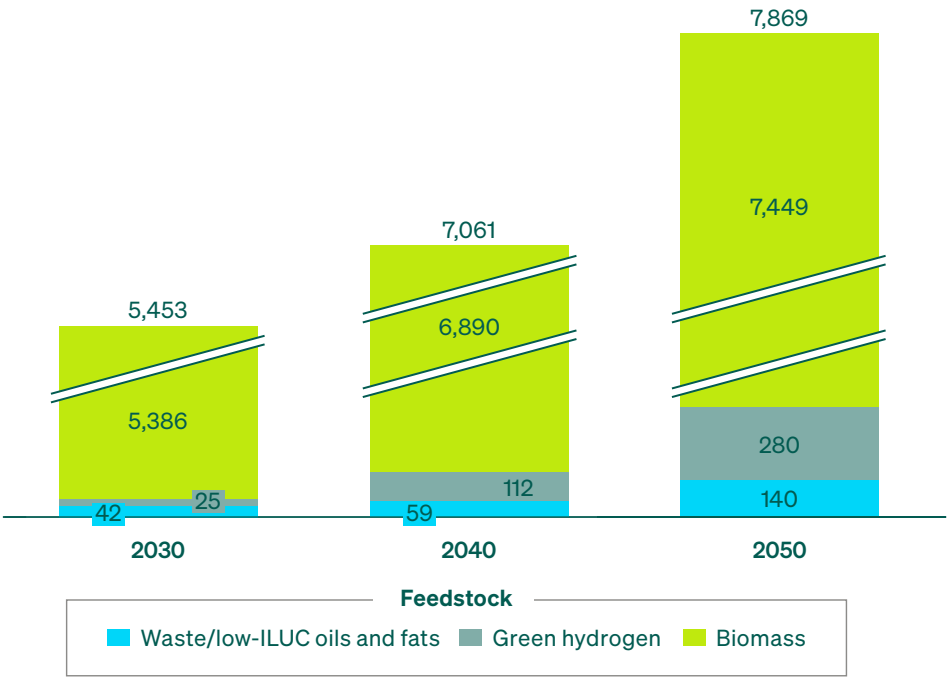


Figure 8: Potential global feedstock availability of waste/low-ILUC oils and fats, green hydrogen and biomass for all end-use sectors. Total biomass availability is estimated at 100 EJ in 2050.

[f] Based on historical deployment of corn ethanol production in the United States

For the HEFA pathway, we assume aviation can claim 50% of the collected waste oils and fats from 2030-2040, increasing to 60% by 2050 driven by the electrification of road transport and potential fuel switching in the maritime sector.

For the biomass pathways, we assume aviation can claim 20% of the available biomass, not taking into account transportation challenges of the low energy density feedstocks and technical challenges to aggregate different types of biomass in one SAF production facility. Aviation will have to compete with other sectors for biomass, such as the other transport modalities (road, maritime), chemicals and industry. However, since aviation has no other option than to use liquid hydrocarbons, we expect willingness to pay in aviation to be sufficiently high to justify a 20% claim. At the same time, renewable fuel refineries using biomass feedstock will produce a range of other hydrocarbons besides jet fuel, such as diesel, LPG and naphtha. These co-production set-ups will contribute to demand for renewable molecules in various end-use sectors.

For e-SAF, we assume a 20% claim on green hydrogen production. We do not take into account potential feedstock restrictions on biogenic CO_2 required for e-SAF production, as ranges for biogenic CO_2 availability until 2050 differ by orders of magnitude. Because CO_2 is captured and shipped more easily compared to hydrogen, we expect hydrogen production to be the main constraint.

Capacity Deployment

With these assumptions, SAF deployment towards 2050 is limited to the maximum pace of development – largely driven by capital expenditures flowing into SAF. Between 500–800 SAF facilities are required to meet the 250 Mt SAF production.[g] Assuming USD 2 billion per facility, this represents a cumulative investment of more than 1 trillion USD.

Capital expenditures required to develop 500 – 800 SAF refineries represents an average annual CAPEX of 40 billion USD between 2025 – 2050. This is roughly equivalent to 8% of global annual upstream oil and gas CAPEX in 2019.

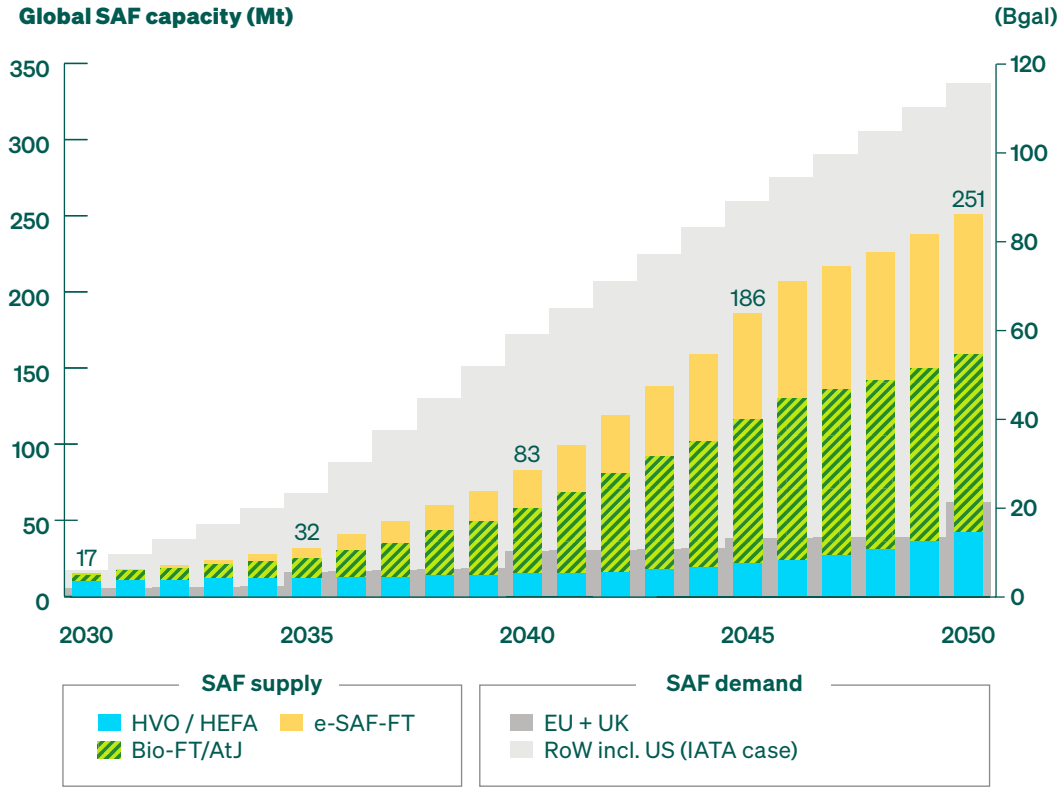


Figure 9: Global SAF capacity ramp up until 2050 based on rapid technology deployment and feedstock constraints.

[g] Assuming 0.3 – 0.5 Mt average SAF output per year per facility.

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About SkyNRG
SkyNRG is a global leader in Sustainable Aviation Fuel (SAF). Since 2009, the company has been scaling up SAF demand and production capacity for the industry to meet its 2050 net zero commitment[h]. SkyNRG was the first in the world to supply SAF on a commercial flight flown by co-founder and shareholder KLM in 2011. To date, SkyNRG has supplied SAF to over 40 airlines across the world and is now developing dedicated production facilities to support the shift from fossil jet fuel to sustainable aviation fuel. As a certified B Corp™ SkyNRG prioritizes producing the most responsible and sustainable SAF worldwide. Recognized as a sustainability leader, it maintains an independent Sustainability Board, which advises the company on feedstocks and provides strategic guidance on wide-ranging sustainability issues. SkyNRG operations are certified against the RSB EU RED, CORSIA, and Book & Claim standards.

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[h] IATA has committed to achieve net zero carbon by 2050 - https://www.iata.org/en/programs/environment/flynetzero/. IATA represents some 320 airlines or 83% of total air traffic https://www.iata.org/en/about/.

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