In collaboration with Kearney

WORLD ECONOMIC FORUM

Scaling Up Sustainable Aviation Fuel Supply: Overcoming Barriers in Europe, the US and the Middle East

INSIGHT REPORT

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Foreword

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The World Economic Forum and Airports Council International (ACI) World are co-leading the Airports of Tomorrow initiative, which seeks to address the energy, infrastructure and financing needs of the aviation industry's transition to net-zero carbon emissions by 2050. The initiative has convened executives from across the aviation sector with an aim of accelerating the move towards increased sustainability and resilience.

This report presents key findings from our work on sustainable aviation fuel (SAF) in 2023. We showcase critical technologies for SAF scaling and their advantages, as well as the greatest challenges at this time. Future SAF volumes have been analysed and optimal global production hubs identified to satisfy this emerging demand. Furthermore, we focused on adequate regulation and policy to enable global SAF scaling, as well as insights and important themes for specific countries and regions.

The report focuses on three regions – Europe, the US and the Middle East – and contains insights from stakeholders in the aviation and energy industries as well as the public sector. The main goal is to provide a comprehensive overview of the existing challenges for SAF adoption and highlight which actions stakeholders along the entire value chain should take to move towards 10% SAF in 2030 and subsequent sector decarbonization by 2050.

This work was developed by the World Economic Forum in partnership with Kearney, ACI World, Airbus and Arup. We thank our partners and industry sponsors for their support.

Executive summary

The aviation sector faces challenges in scaling SAF, requiring collective efforts to accelerate technology deployment, secure demand certainty and establish conducive regulatory frameworks.

Air travel contributes 2–3% of global CO_2 emissions,[1] primarily due to aircraft fossil fuel consumption. Furthermore, the projected demand for aviation fuel could surge by over 50% by 2050 compared to 2019, increasing this share significantly.[2] Despite recognition of the importance of sustainable aviation fuel (SAF) in decarbonizing the industry, global production remains insufficient, with announced projects covering only 30–40% of the aspirational 10% of global fuel supply in 2030.

Solving this supply shortage requires deploying existing and developing novel technologies in regions with favourable conditions. Appropriate regulations and policies are also needed to create a SAF market given that SAF production is currently two to five times costlier than fossil jet fuel.[3]

Europe has been leading the way on many policies aimed at advancing the decarbonization of its economy, such as the implementation of emissions trading systems (ETS) and adopting the ReFuelEU legislation, committing to tangible SAF mandates of up to 70% of fuel supply by 2050.[4] Stakeholders are now focusing on collaboration in technology development, providing transparent SAF properties and committing to long-term SAF agreements. The public and private sectors will need to come together to unlock the significant investments required to scale.

In the **US**, financial incentives are stimulating technology development and deployment. The Inflation Reduction Act (IRA) contains tax credits for producers. Local legislation, especially on the west coast, aims to attract production. Without mandates, the industry is looking for partnerships to ensure long-term offtakes and tangible risk-sharing agreements. Extending both the duration and availability of federal incentives can provide greater planning security for new production facilities.

In the **Middle East**, local conditions and the region's role as a global aviation hub are favourable for the production of SAF. With cheap renewable energy, access to finance and established export networks, the region could become a hub for power-to-liquid (PtL) fuels. However, without comprehensive and favourable SAF regulation, players currently focus on greening existing fossil refineries and producing lower-carbon aviation fuel (LCAF). Increased public awareness and closer public–private collaboration are imperative. The region will likely adopt a fast-follower role, deploying technology once it has been proven elsewhere.

Stakeholders globally agreed that the following key activities will enable the rapid scaling of SAF:

- **SAF and energy producers** should focus on deploying effective SAF production capacities and look for long-term demand certainty to de-risk the required funding.
- **Airports** can act as impartial matchmakers, encouraging SAF partnerships, driving public awareness and promoting SAF uplift through incentives (e.g. direct subsidies or modulated landing fees).
- **Airlines** need robust supplier partnerships to access competitive SAF. In return, they should commit to long-term offtake agreements and potential co-investment in production facilities.
- **Original equipment manufacturers** (OEMs) must ensure compatibility of future engines, fuel systems and aircraft with 100% SAF. Furthermore, they should support technology development through extended partnerships.
- **Corporate customers** can take the lead in covering the green premium cost for SAF, while at the same time providing technical knowledge.
- **The finance sector** must increase green investments, participate in funding for SAF and collaborate with the industry to develop and de-risk robust business cases.
- **Governments** are increasingly recognizing the importance of SAF and should pass legislation to support the market build-up.

The success of SAF scaling hinges on strategic partnerships, targeted technology deployment and supportive regulations and financing mechanisms.

Introduction

Global collaboration, investment and supportive policies are needed to bridge the projected demand-supply gap in 2030 and beyond.

Challenges in production and technology adoption remain. In addition, regional factors – such as available technologies, favourable production conditions and policy landscapes – significantly influence SAF deployment strategies.

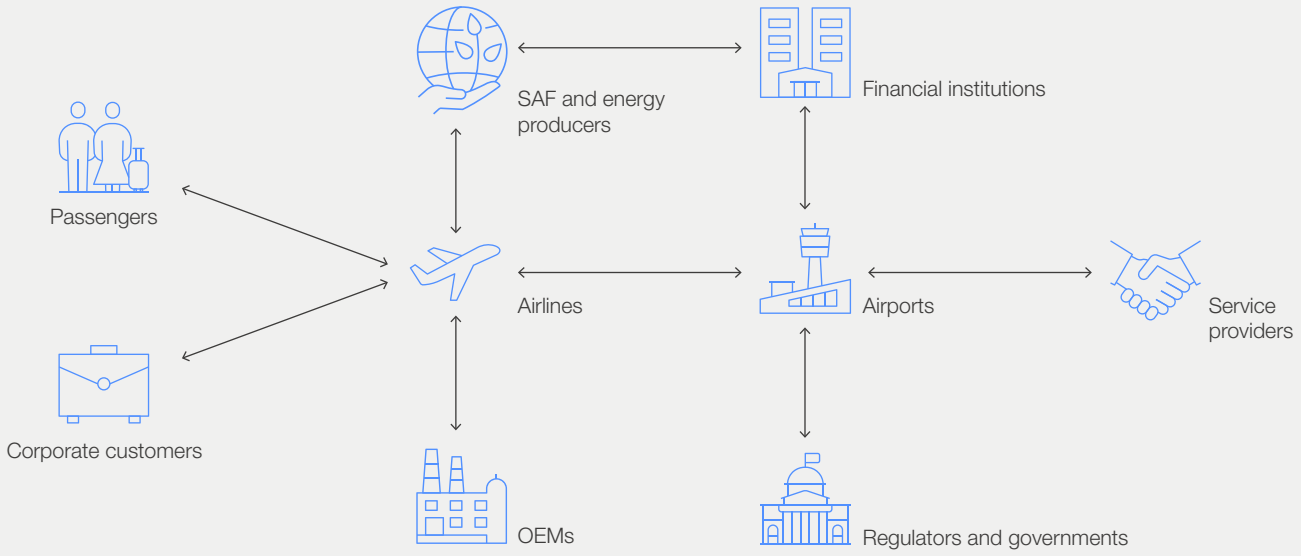
Importance of SAF in aviation decarbonization

The aviation sector is a hard-to-abate sector amid efforts to reach a net-zero world in 2050, currently causing 2–3% of global CO_2 emissions.[5] The key decarbonization challenges arise from the high energy densities required for aircraft and the lack of zero-emission propulsion commercially viable today, as found in other sectors such as road transport. While solutions such as improved operational efficiency, hydrogen and electric aviation will help the industry decarbonize, it is the consensus that these activities will, for the next decade, be insufficient to advance the net-zero transition. Presently, the critical solution to deploy is sustainable aviation fuel (SAF), which is estimated to account for most environmental impact reduction until 2050. The main reasons for this are the possibility for rapid scaling (if current barriers are overcome), seamless integration into existing fuel infrastructure and additional benefits, such as lower sulphur dioxide (SO2), nitrogen dioxide (NO2) and particulate emissions reducing air pollution.[6]

Although it is estimated that SAF will comprise 65% of the energy mix for aviation in 2050, according to the International Air Transport Association (IATA),[7] current production remains low despite an increased wave of announcements and commitments to ramp up production globally. During the recent third International Civil Aviation Organization (ICAO) Conference on Aviation and Alternative Fuels (CAAF/3), the industry agreed to strive for an effective CO_2 emission reduction of 5% by 2030,[8] while the signatories of the Clean Skies for Tomorrow 2030 ambition statement aspire to a 10% SAF share of fuel supply by the same year.[9]

Realizing both of these milestones will require more rapid deployment of production capacities. Collaboration among all stakeholder groups in the aviation ecosystem (see Figure 1) will be essential to enable this transformation.

FIGURE 1: **Simplified overview of the aviation and energy industry ecosystem**



Source: Kearney and Airports of Tomorrow

Projected SAF demand-supply gap in 2030

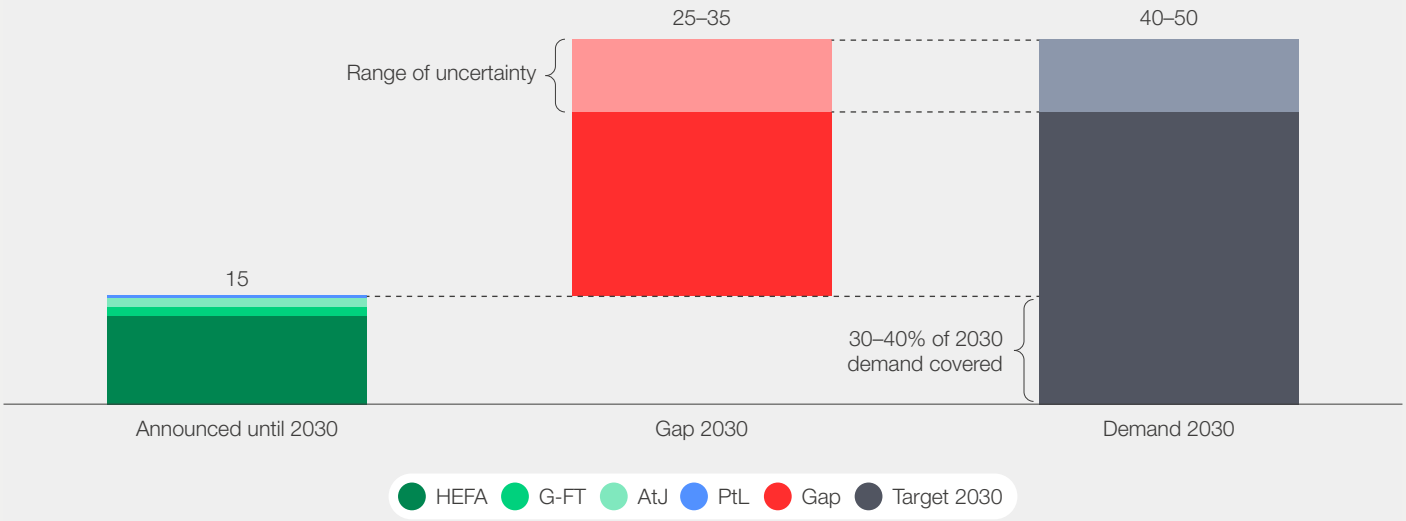
Achieving 10% SAF in global fuel supplies by 2030 is crucial to kickstart aviation decarbonization and prove that the rapid scaling required in the following decades is possible. Considering recent aviation fuel consumption factors,[10] and estimated regional growth factors,[11] global fuel demand in 2030 is estimated at 400–500 metric tonnes (Mt) annually. A total of 40–50 Mt of SAF would thus be needed to reach the Clean Skies for Tomorrow ambition. However, looking at currently announced projects until 2030, only 30–40% of this demand would be covered (see Figure 2).[12] This is mostly due to technology risk, lack of funding and market uncertainty leading to a hesitancy among fuel producers to invest in new production sites and infrastructure.

Another notable issue is the opacity of SAF prices (both bid and offer), which is a natural consequence of the still low volumes of exchanged quantities. Prices are often privately negotiated and not transparent to the wider market. This lack of transparency and liquidity poses additional friction to fast SAF deployment across the world.

The creation of a global SAF marketplace would go a long way in resolving these transparency and liquidity issues, facilitating trading and helping to close the still-too-wide spread between bid and offer prices.

FIGURE 2. **Only 30–40% of the projected 10% SAF demand in 2030 is covered by current project announcements, with the majority coming from HEFA-based production**

Currently announced production capacities fall 25–35 Mt/year (~60–70%) short of delivering on 10% global SAF share in 2030[1]



1. Considered project stages: planning, investment decision, construction and operation.
Note: HEFA = hydro-processed esters and fatty acids; G-FT = biomass gasification Fischer-Tropsch; AtJ = alcohol-to-jet; PtL = power-to-liquid.
Source: Kearney and Airports of Tomorrow

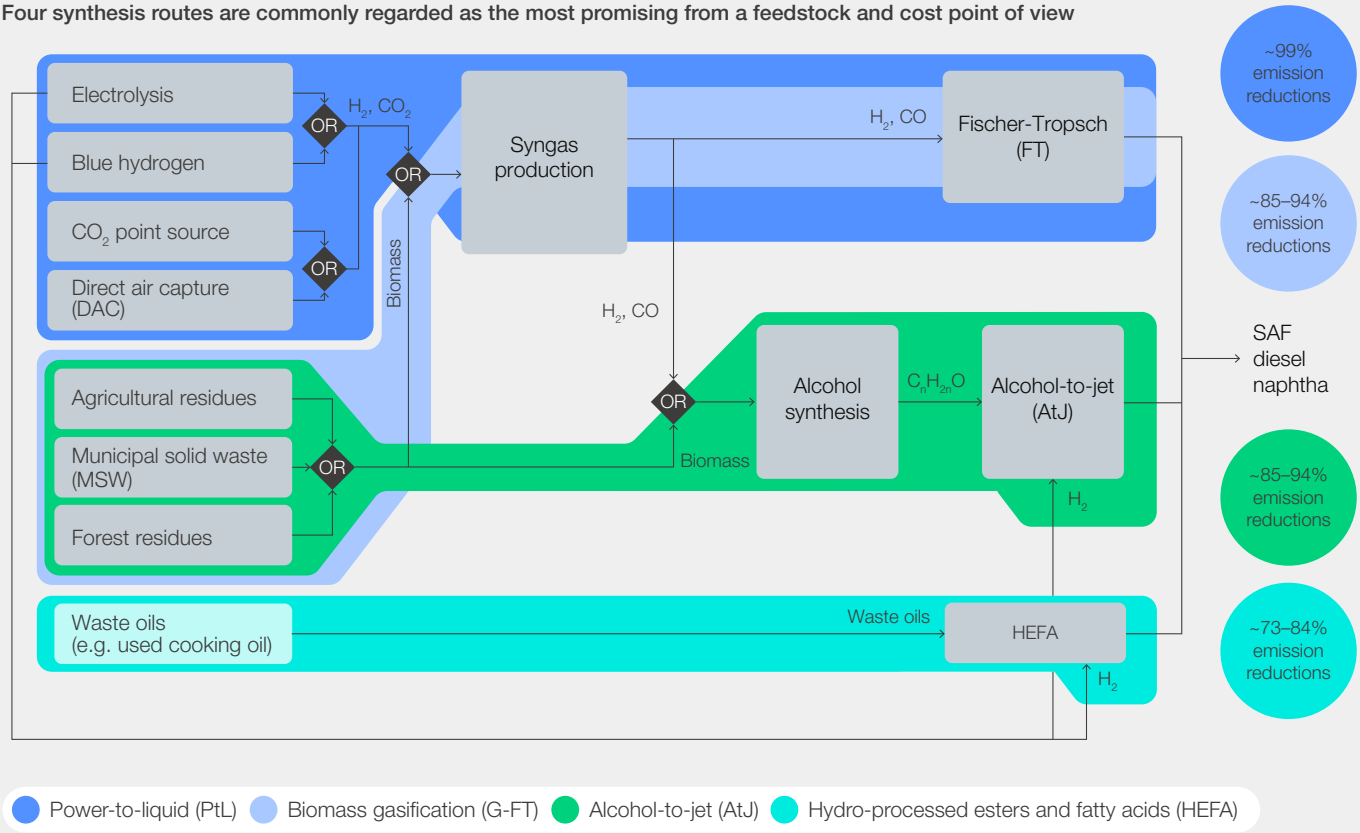
Available technologies and their key challenges

SAF is generally produced from biogenic or non-biogenic sources and has the potential to reduce CO_2 emissions compared to fossil jet fuel by up to 99% on a life-cycle basis, depending on the production route.[13] When blended with conventional fuel (Jet/A1), its chemical and physical properties are comparable and certified as compatible with "conventional" Jet/A1 fuel. One of the main differences between the "neat-SAF" and kerosene (Jet/A1) is the absence of aromatics, leading to issues with sealing O-rings and with lubrication in aircraft engines. Such an issue is solved and monitored by using blends between "neat-SAF" and conventional fuel to obtain a SAF that complies with the expected fuel specifications. As of July 2023, the American Society of Testing and Materials (ASTM) has approved several pathways,[14] which are also the ones recognized by ICAO. The ASTM additionally specifies the respective maximum SAF blend ratios with conventional jet fuel, with the maximum approved SAF ratio currently at 50%, which ensures safe operations of current aircraft and engine systems.

This report focuses on the four most promising ASTM-approved pathways to be deployed at scale in the coming decades (see Figure 3): hydro-processed esters and fatty acids (HEFA), biomass gasification (G-FT), alcohol-to-jet (AtJ) and power-to-liquid (PtL).

FIGURE 3. | **Key SAF production pathways rely on similar technology building blocks**

Four synthesis routes are commonly regarded as the most promising from a feedstock and cost point of view



Source: Kearney and Airports of Tomorrow

1. **Hydro-processed esters and fatty acids (HEFA)**
   HEFA is currently the most common SAF pathway globally and uses waste and residue oil feedstocks, such as used cooking oil or purpose-grown oil-yielding plants. To improve the production yield, hydrogen is also fed into the process. However, significant cost reductions in the coming years are unlikely as the technology is mature and the increased demand has recently resulted in rising feedstock cost. In addition, sustainability challenges around purpose-grown oil-yielding plants limited the scaling potential of HEFA towards 2050.

2. **Biomass gasification (G-FT)**
   The gasification of biomass produces a mixture of hydrogen and carbon monoxide (e.g. syngas), which is used to produce SAF in a Fischer-Tropsch reactor. Based on the wide array of usable feedstocks, two subtypes are generally distinguished: biomass-to-liquid (BtL) and waste-to-liquid (WtL). The required technologies are understood, and cost improvements through scaling may be possible. One key cost driver is the choice, collection and energy content of the feedstock, often requiring smaller decentralized production. Preprocessing of biomass close to the source can enable larger centralized SAF production sites.

3. **Alcohol-to-jet (AtJ)**
   The AtJ pathway can process any feedstock that can be processed to alcohols (for instance, ethanol or methanol) and converts them into SAF with a high specific yield. Bioethanol is already a widely produced product today and could be redirected to scale SAF production quickly until 2030. Furthermore, local processing of biomass feedstocks into alcohols allows larger-scale centralized production, enabling additional cost savings. All required technologies are well understood and have been individually deployed within industrial sites. The extent to which cost reductions are possible is unclear.

4. **Power-to-liquid (PtL)**
   Hydrogen (H_2) and CO_2 from engineered rather than biological processes are used to produce PtL SAF, making it the only pathway that is not limited by biomass feedstock availability in the long term. H_2 used in this way can be produced via electrolysis (e.g. green H_2) or from fossil sources, if the emitted CO_2 is captured and permanently stored (e.g. blue H_2). CO_2 can originate either from appropriate point sources (e.g. biomass energy) or direct air capture (DAC). A key challenge that drives most of the cost is the affordability and accessibility of vast amounts of (renewable, in the case of green hydrogen) energy. Affordability is strongly

dependent on local conditions and policies, making the strategic positioning of these facilities crucial. With both electrolysis and DAC being emerging technologies, significant capital expenditure (CapEx) savings are likely in the next decades, but PtL remains the most expensive pathway today.

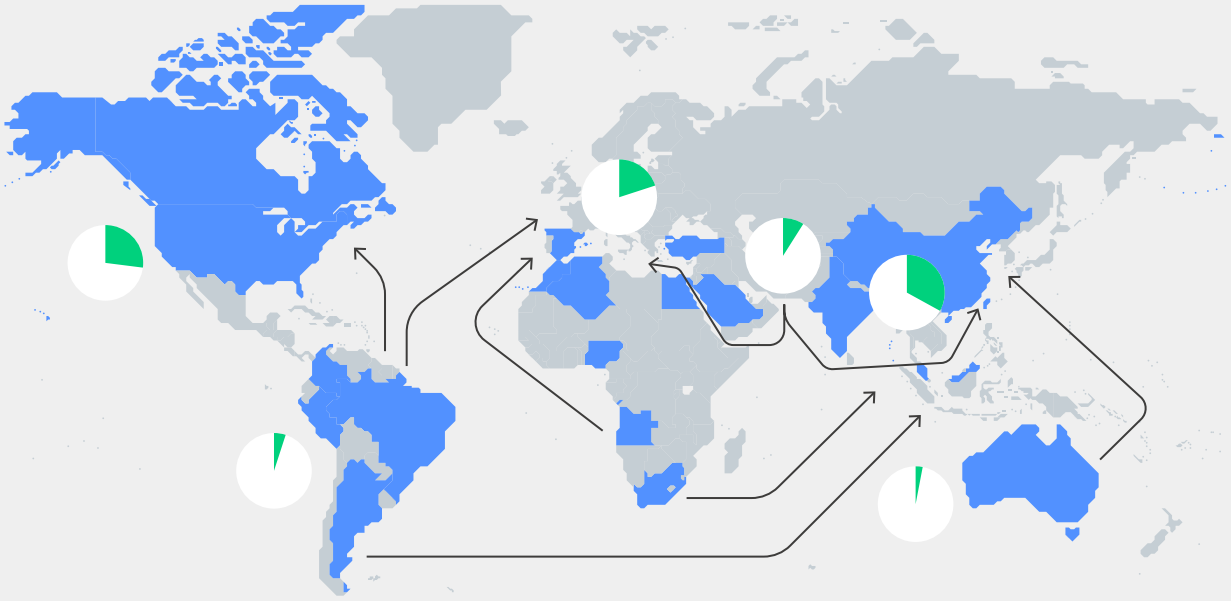
Favourable regions for SAF production

SAF is a liquid fuel, like conventional fuels, and can be transported through existing global transport networks. As a result, production facilities can be built in regions with ideal conditions, enabling the cheapest and most efficient production to fulfil the emerging global demand.

Several factors influence how favourable a location is to produce SAF from technical and economic standpoints (e.g. not considering any policies or regulations). The most important aspect is the availability of cheap local green energy (electricity and heat). Next, the feedstock availability (e.g. types and quantities) and associated costs are key for the right technology choice. Additional factors to consider may include existing feedstock logistic systems, labour costs and relevant local expertise and infrastructure.

FIGURE 4. **Overview of most favourable regions to produce SAF as well as forecasted SAF demand in 2030**

Green SAF export corridors will likely evolve by 2030, serving global demand through competitive production sites



Top 20 production location[1] ⟶ Green SAF corridors Regional share of global demand at 10% SAF[2] [%]

1. Based on the most competitive production cost regardless of deployed technology; 2. Based on EIA data and regional growth projections until 2030 from Mission Possible Partnership, *Making Net-Zero Aviation Possible: An Industry-Backed, 1.5°C-Aligned Transition Strategy* (2022).
Source: Kearney and Airports of Tomorrow

Considering these factors, 20 key regions were identified globally, which are well positioned to scale local SAF production (see Figure 4). Some of them overlap with projected SAF demand centres in 2030 (e.g. North America, China, India). At the same time, many ideal production locations are in South America, southern Africa, Australia and the Middle East. Surplus production in these regions can thus be expected to be available for export. Regions with less favourable conditions, such as Europe and Japan, should produce SAF locally where it makes sense economically and in terms of national energy security, while obtaining the remaining quantities from overseas.

The result of these considerations is the likely formation of international green SAF corridors, which will connect production hubs with demand centres internationally. The setup of such supply chains is very complex and requires time, even if existing networks can be used. An alternative could be the implementation of credible “book and claim” systems, which aim to decouple the environmental benefits of SAF from its physical flow. In doing so,

a European airline could, for instance, purchase SAF at competitive prices in Australia and claim the related emission reductions, while the fuel is physically injected and used at an Australian airport.

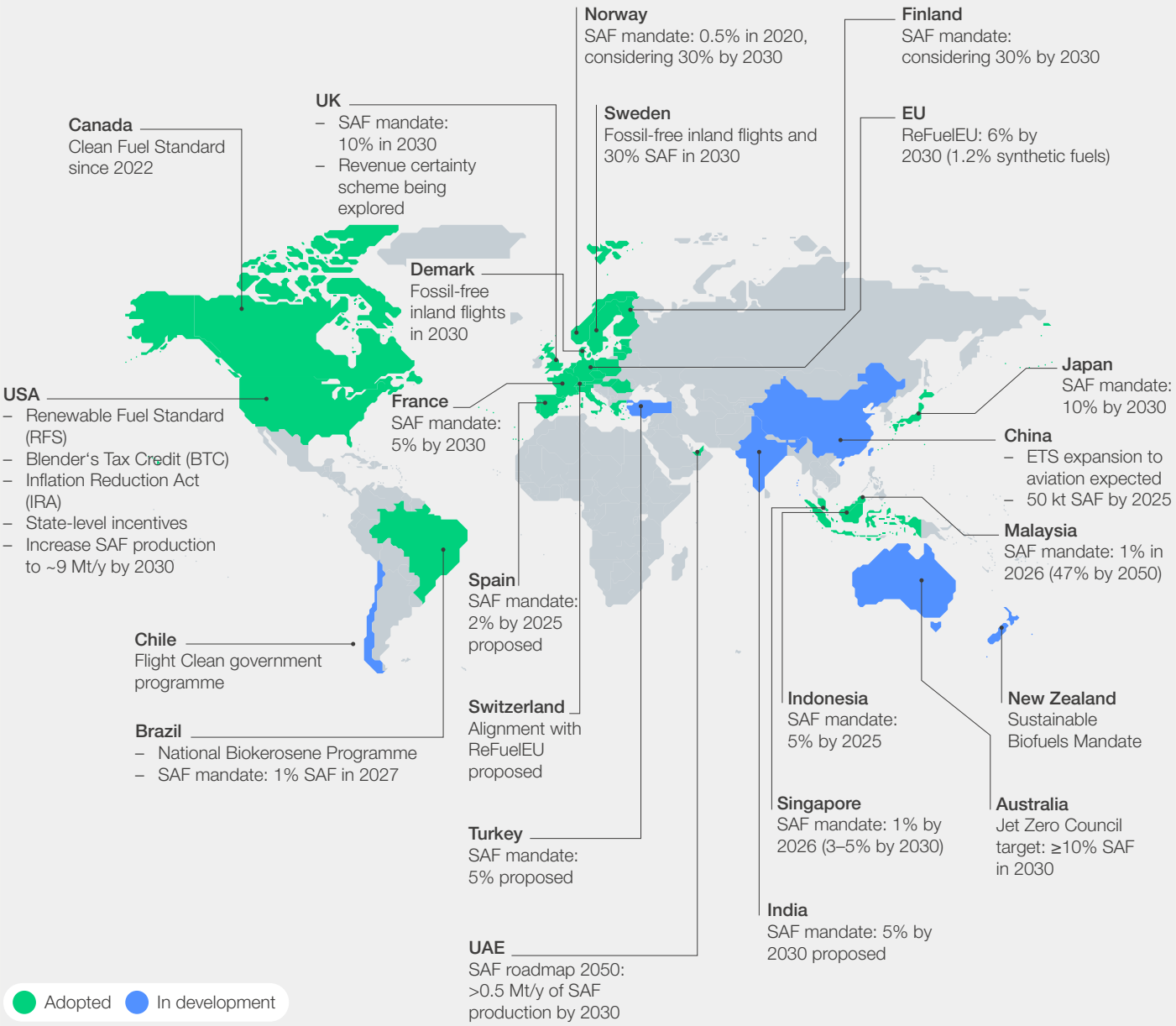
Through this process, the cost and complexity of intercontinental transport can be avoided and SAF adoption supported. Book and claim can thus be a vital component in creating more momentum around SAF; however, it is paramount that the system is credible, ensures traceability and avoids unwanted effects such as double counting of environmental benefits. Additionally, the importance of such systems will decline as the SAF share is gradually increased and fossil fuels are phased out.

Current global policy landscape

Another key aspect that heavily influences and potentially shifts the regional technical and economic perspective detailed above is the local regulatory and policy environment. Around 75% of projected global fuel demand in 2030 is covered by either discussed, proposed or already adopted regulation, affecting regional competitiveness (see Figure 5). The most advanced regulations have been passed in Europe and the US, relying largely on mandates and incentives, respectively. Other regions with significant activity are in Asia and Oceania, which are actively discussing the implementation of SAF mandates.

FIGURE 5. **Overview of SAF-related policies being developed or already adopted globally**

Discussed and adopted SAF policies cover ~75% of fuel demand globally and will affect regional competitiveness



Sources: ICAO,[15] ACI,[16] IEA,[17] Eurocontrol,[18] *Biomass Magazine*,[19] S&P Global[20]

The individual countries' approaches vary significantly in their nature and ambition, but they can be broadly clustered into three categories:

1. **SAF mandates**
   SAF mandates are key components of the recently passed ReFuelEU legislation in Europe, which obliges fuel suppliers to supply an increasing SAF quantity annually.[21] Similar considerations are being discussed in countries such as India, Japan and Brazil. While this approach creates demand certainty and reduces risk, it does not actively support the scaling of production on its own, unless any penalty fees for non-compliance are used to finance SAF projects.

2. **Taxation of carbon emissions**
   Tracking and taxing carbon emissions resulting from fossil fuel consumption enables the pricing in of their negative externalities (e.g. global warming). Taxing CO_2 at an appropriate level can close the cost gap to green fuel alternatives, while at the same time generating revenue that can be reinvested in sector decarbonization. The main risk is a decreased competitiveness of the taxed region, making careful policy design crucial. The most advanced emissions trading system (ETS) including aviation exists in the EU, with other examples being implemented in the UK, California and China, the latter of which is expected to become the largest domestic aviation market in the world.[22]

3. **Financial incentives for SAF production**
   Financial support of green fuel production aims to close the gap with fossil fuels by reducing the financial burden of developing and deploying SAF production technologies. This can take various forms, such as tax credits granted to producers in the US,[23] or revenue reassurance mechanisms, which the UK has committed to implementing.[24] Such support options are not limited to the public sector alone, showcased by airport-level financial incentives given to airlines with a higher SAF fuel uplift, such as at Heathrow Airport.[25]

While aviation is a global industry, not all regions are progressing uniformly in the enablement of SAF scaling. Three of these regions are discussed in detail in the following sections.

1 Scaling SAF for Europe

Europe faces challenges including limited agricultural land, high energy costs and low bio-feedstock availability, but is quite advanced in regulatory initiatives.

1.1 European situation and challenges

Europe represented around 20% of global jet fuel demand, or 75 Mt per year, in 2019,[26] which is set to increase to 90 Mt in 2030. To reach 10% SAF in the fuel mix by 2030, around 9 Mt of SAF is thus required, which will likely not be possible via regional sources alone.

As Europe is a densely populated region, the potential to use agricultural land for dedicated feedstocks is limited. Traditionally this has been seen critically by regulators due to potential competition with food production. Some southern and northern regions with high solar and wind power availability may be suitable for synthetic fuel production. However, the question of suitable carbon sources remains. At the same time, high energy costs and low bio-feedstock availability constrain local supply and will likely make imports necessary, requiring adequate certification of imported fuels to uphold sustainability requirements.

Nevertheless, Europe has been a pioneer in developing and passing impactful legislation to create market demand and encourage SAF production.

1. **Emissions trading systems (ETS)**
   The EU pioneered the use of emission taxation via the implementation of the EU ETS, which covers all flights between member states and departing from the EU to international destinations. The pressure on the aviation sector has recently increased through the phase-out of free emission allowances under the Fit for 55 package, with full allowances auctioning starting in 2027. Additionally, the emission cap will be continuously decreased by more than 4% annually.[27] To support the uplift of SAF, 20 million SAF allowances will be granted for free until 2030.[28] In the case of the ETS, the emitter (e.g. the airline or aircraft operator) is required to pay for its emissions and faces high fines in case of pollution without proper permits.

2. **SAF mandates**
   The landmark ReFuelEU legislation was adopted in 2023 and requires fuel suppliers to blend defined SAF quantities into their fuel deliveries, starting in 2025. In 2030, ReFuelEU will require an overall blend of 6% SAF, with the blending requirements increasing gradually to 70% in 2050. The regulation additionally comprises sub-mandates for synthetic fuels derived from H_2 and CO_2 (1.2% in 2030, 35% in 2050).[29] The UK is also developing a SAF mandate, which will likely require a 10% SAF share in 2030.[30] The EU taxonomy, a classification system for environmentally sustainable activities, also sets a target of minimum 15% SAF by 2030, which provides a strong demand signal for taxonomy-aligned aircraft.[31]

1.2 Key actions to take

With this strong regulatory framework and the clear signal that Europe wants to lead on SAF, industry stakeholders are looking for ways to ramp up production to comply with ReFuelEU mandates.

Ten important topics, which require increased activity by all actors, dominate current discussions, and they can be clustered into three categories: collaboration, finance and policy.

FIGURE 6: **Results from the European SAF Pulse survey among aviation and energy industry stakeholders (30 participants)**

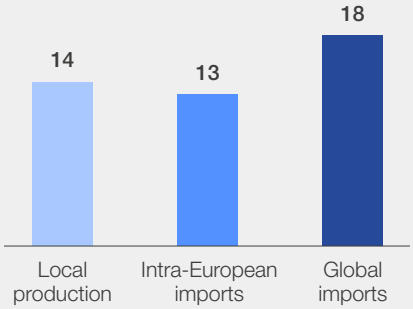
European SAF Pulse survey among aviation and energy industry stakeholders

Participants: 30 private and public-sector organizations

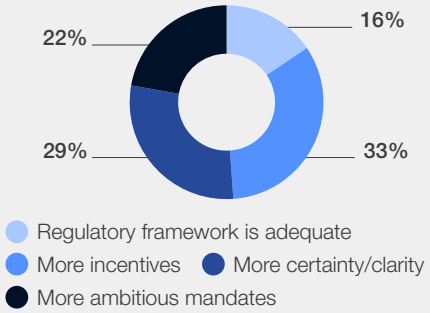
Note: Figures on bar charts may reflect the number of responses to each entry rather than the number of participants as in some cases respondents could vote for more than one option.

Source: Kearney and Airports of Tomorrow

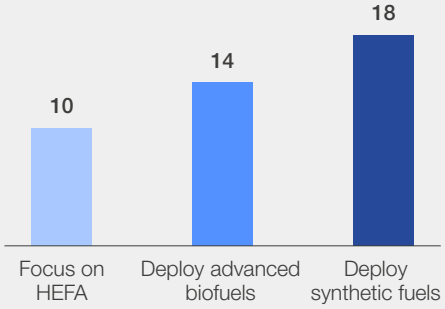
Which SAF supply options will be relevant for Europe in 2030?



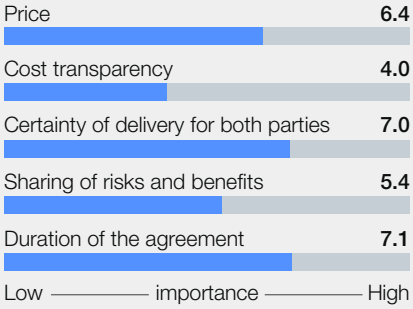
Are current policies adequate to support SAF scaling or which additions do we need?



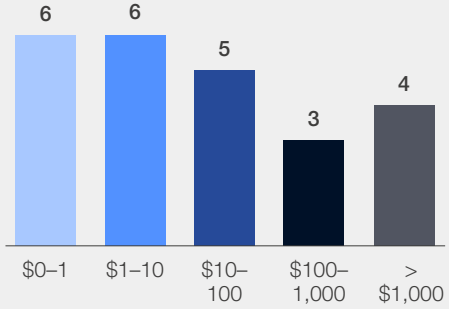
What are key technology strategies to scale SAF until 2030?



Which aspects are most important in negotiating SAF supply contracts?



How much would your organization co-invest in a SAF production facility? ($ million)



1.2.1 Collaboration

1. Collaborate on regional SAF supply strategy

Key stakeholder groups: Airlines, airports, SAF producers, governments and regulators, OEMs, service providers

European stakeholders expect global and intra-European imports (e.g. Iberia, Nordics) of SAF to play a major role in 2030 (see Figure 6). While local production will be important as well, Europe can contribute even more effectively to global SAF scaling through technology leadership and export. When structuring industry collaborations, benefit- and risk-sharing solutions as well as cost-transparency mechanisms can enable strong demand signals and investments in SAF scaling.

Another key aspect in supporting SAF scaling is to ensure transparency of all available support options. Using the platform and resources provided by regulators can contribute to solving bottlenecks and requesting the predominantly financial resources required to reach the SAF goals. Additionally, airports and service providers can act as impartial matchmakers for sector collaboration by facilitating negotiations between different stakeholders, setting up working groups, participating in feasibility studies and processing test flights. Partnerships for supply strategies are especially needed among fuel producers, technology providers and feedstock providers. Connecting the right parties can be facilitated through industry groups, allowing alignment of their respective SAF strategies.

2. Provide transparent and traceable SAF properties

Key stakeholder groups: SAF producers, service providers, airports

OEMs, service providers and aircraft operators rely on standardized fuel properties provided by the fuel suppliers to ensure safe engine and aircraft operations. This also includes ensuring the compatibility of different SAF types with all produced aircraft systems and collaboration with engine manufacturers to ensure similar engine performance. In addition, transparency and traceability of the environmental benefits (e.g. carbon intensity) of supplied SAF are key as they allow decarbonization efforts to be tracked and must be reported under the ETS systems.

Key performance indicators in this context are feedstock type and its sustainable properties, technology pathway, production location and total carbon footprint.

3. Commit to long-term SAF agreements

Key stakeholder groups: Airlines, SAF producers, governments and regulators

Long-term fuel-offtake contracts are essential to ensure certainty for fuel suppliers and airlines. Additional stakeholders that can be involved are airports, customers and especially corporate customers, depending on the contract structure. Streamlining contract negotiations can be achieved by using existing templates and accelerating contract development.

European stakeholders consider price, certainty of delivery and the long-term duration of contracts as the most crucial contract elements (see Figure 6). Additionally, contracts should include risk- and benefit-sharing mechanisms to give credibility to the project and enable access to capital.

Airlines should be allowed to profit from technology improvements, which may be done via transparent "cost plus" schemes whereby airlines commit to paying the price premium for SAF regardless of what the production cost is. Stakeholders can additionally support SAF producers by sharing technical knowledge, financing early development phases and CapEx co-investment for production scaling.

4. Raise passenger awareness about SAF

Key stakeholder groups: Airlines, airports, governments and regulators, service providers

Involving consumers more actively can significantly contribute to rapid SAF adoption. Currently, the public does not have a tangible vision of a sustainable aviation sector. One way the industry could change this is through specific marketing campaigns including, for instance, short stories showcasing the implications for pilots, cabin crews and passengers in the future.

To help cover the initial price premium, industry could identify ways of socializing the price premium of SAF and encourage an increasing willingness to fly sustainably. A clear communication of the positive climate impact of SAF can be structured in different forms: publicly announcing the inclusion of SAF in sustainability strategies, as well as the commitment to short- and long-term targets, is recommended for all stakeholder groups. In doing so, existing and new partnerships in the sector should be used to reach a wider audience.

1.2.2 Finance

1. Invest in SAF research and development to improve cost and sustainability

Key stakeholder groups: SAF producers, OEMs

Reaching 10% SAF globally by 2030 will largely depend on the deployment of available production pathways, for which alternative cost-effective feedstocks should be deployed. Investment in new technologies promising higher SAF yields at lower cost and lower carbon intensity are also needed to enable continued scaling in the next decades. European industry evaluates the deployment of advanced biofuels (e.g. AtJ) and synthetic fuels (e.g. PtL and sun-to-liquid) as important even in 2030 (see Figure 6).

Using adequate carbon sources for synthetic fuels will be key and will mostly rely on biogenic sources, which can be made more readily available through biomass growth on marginal land. Furthermore, biogenic and synthetic pathways for SAF can be deployed together to increase overall carbon efficiency.

Many publications and articles tend to be overly optimistic about future cost-down potentials, which can complicate financing and supply negotiations.

An industry-backed publication highlighting this and showing more realistic cost ranges (especially for early-stage technologies) could help manage expectations and facilitate contract negotiations between investors and industry.

2. Encourage investment to scale SAF supply

Key stakeholder groups: Airlines, airports, SAF producers, OEMs, governments and regulators, service providers

Scaling SAF production, especially in the short term, relies on access to adequate funding. While European stakeholders are willing to invest significant amounts in SAF scaling (see Figure 6), a key factor in enabling these investments is improving the overall SAF business case and providing demand certainty.

As part of building an attractive business case, getting initial financing (e.g. "catalytic money") and de-risking the project are crucial. Catalytic money can come through easier access to innovation funds, creating awareness of financing needs and creating a "coalition of the willing" (for instance, airports, airlines and investors). De-risking the business case could be done via contracts for difference and offtakes from buyers with credible balance sheets (e.g. military and airline alliances/coalitions).

Governments and regulators can support this by reinforcing policies that support blending mandates, developing subsidies and implementing price certainty mechanisms. The concept of "blended finance" will be important to finance first-of-a-kind technology and scale proven technology to make them commercially viable, both in terms of production volumes and price. It should be noted that the energy supply may also be subject to specific regulatory changes. Energy and transport regulations will thus need to be coordinated. Corporate buyers can additionally improve the business case by committing to SAF purchases to reduce their Scope 3 emissions. OEMs are investing in SAF supply scaling via the support of start-ups developing new technologies and providing mentorship, access to technical facilities as well as financial support and early-stage funding to SAF disruptors.

3. Build infrastructure for SAF roll-out

Key stakeholder groups: Airports, SAF producers, governments and regulators, service providers

SAF supply depends on the scaling of production and adequate blending and distribution infrastructure, requiring significant investments. Access to airport fuel supply systems can be facilitated for all SAF suppliers through adequate partnerships with incumbent players and infrastructure operators. Additionally, the feasibility of on-site SAF blending facilities within airport perimeters should be evaluated to accelerate adoption in addition to off-site blending within existing refineries. Adequate financing mechanisms should be developed and deployed to enable the required large CapEx investments of infrastructure build-out.

1.2.3 Policy

1. Define clear standards and regulations for SAF

Key stakeholder groups: SAF producers, governments and regulators

Clear standards and regulations, as well as avoiding regional disparities within a regulated market, are key to enabling long-term planning security for SAF producers. While some stakeholders view current regulations to already be adequate, many are looking for more incentives, more ambitious mandates and more certainty/clarity (see Figure 6). This is especially important with regard to the eligibility of feedstocks, access to affordable renewable energy and technology pathways, which should be clearly and transparently defined by regulators.

Working with international organizations (e.g. the GHG Protocol) is encouraged in order to define SAF carbon accounting rules and accountability mechanisms. Clear accounting rules enable collaborations with corporate buyers (e.g. Scope 3 emission reduction), which, in turn, help airlines cover SAF premiums. Book and claim systems can be a vital component of this, and their feasibility across the entire value chain should be reviewed (e.g. SAF supply to airports, enhanced traceability to avoid double counting).

Stakeholders can support this process by communicating the importance of SAF for aviation decarbonization to regulators, performing feasibility studies and collaborating with the public sector on the creation of appropriate SAF standards and policies.

2. Align incentives to help with SAF premiums

Key stakeholder groups: Governments and regulators

Short-term incentives can be useful in stimulating SAF production and enable cost efficiency through economies of scale and technology development. They can also help subsidize the price premiums for airlines and ensure their continued international competitiveness under the ReFuelEU mandates. Possible options to reduce the financial risk of investments include: a) contracts for difference; b) revenue assurance schemes; c) using carbon credit revenues from polluting industries to cover the SAF price premium; and d) dedicated funding programmes.

3. Include airport SAF incentives for airlines

Key stakeholder groups: Airlines, airports

In addition to public incentives, airports may have the option of launching SAF incentives as well, assuming their circumstances (e.g. regulations) allow it. A bidding system can be used to reduce SAF price premiums through additional emission charges in case of low SAF adoption, and landing fee discounts can be granted for airlines adopting SAF faster. Where local regulations allow it, including an airport-specific minimum SAF blend target can increase pressure on the system, supporting the ramp-up to fulfil mandates in 2030 and beyond.

2 Scaling SAF for the US

Initiatives such as the IRA support SAF growth, emphasizing collaboration, finance and policy actions, but lack long-term planning certainty.

2.1 US situation and challenges

The US represented almost one-quarter of global jet fuel demand, or 81 Mt per year, in 2019,[32] which is set to increase to 101 Mt in 2030. To reach 10% SAF in the fuel mix in 2030, around 10.1 Mt of SAF is required, which can likely be covered by local production. The SAF grand challenge launched in 2021 reflects this as well. It aims at 9 Mt domestic SAF production in 2030 and supplying 100% of domestic jet fuel demand by 2050.[33] Given the right incentives, surplus quantities might be available for export.

The US exhibits a traditionally strong agricultural backbone, and sufficient available land for dedicated biomass production can be made available, assuming its use is prioritized for SAF production. In contrast to Europe, SAF producers in the US may find there is greater local acceptance of a broader range of feedstocks that may conflict with food production (e.g. corn). Additionally, renewable power is readily and cheaply available in multiple states, such as Texas and California. In combination with local state-level incentives, this represents a great environment for scaling production.

However, regulation in recent years has especially favoured the production of biodiesel instead of SAF, which is why most existing facilities are optimized towards diesel production. A key factor in this is that a biodiesel blending mandate for road transportation is in place under the Federal Renewable Fuel Standard (RFS) programme, while SAF mandates have been heavily contested by industry. In addition, the lack of a uniform carbon price is holding back SAF from achieving a more attractive price relative to conventional jet fuel.

Recent regulatory activities in the country aim to improve this situation, generally following a “carrot” approach (e.g. incentives), which contrasts with the “stick” approach (e.g. mandates) in the EU.

1. **Federal Inflation Reduction Act (IRA)**
   The landmark IRA was signed into law in 2022 and aims to revitalize the energy industry in the country. The IRA raises raises SAF support under the blender’s tax credit (BTC) to provide $1.25–$1.75 per gallon of SAF, depending on its carbon intensity (while maintaining only $1 per gallon for diesel).[34] A minimum of 50% CO_2 emission reduction is needed to be eligible.[35] By the end of 2024, the BTC will be replaced by the clean fuel production credit (CFPC). Additionally, the production of H_2 is supported by up to $3 per kilogram, which can indirectly support the PtL pathway.[36]

   Key downsides are the short duration of these mechanisms. The CFPC is currently set to run only until 2027 and must be extended every two years thereafter, while the support of H_2 production applies for just 10 years if construction starts before 2033.

2. **Federal Renewable Fuel Standard (RFS) programme**
   The RFS programme, originally launched in 2005 and expanded in 2007, requires oil refiners and fuel importers to blend annually increasing quantities of renewable fuel into the transportation sector fuel supply. Compliance is tracked through the renewable identification number (RIN) system, under which SAF producers receive 1.6 x RIN (D4)[37] for each gallon of SAF supplied, which varies based on market demand.[38]

3. **State-level incentives**
   Several states have taken the initiative to launch regional incentives, such as the low carbon fuel standard (LCFS) in California, Oregon and Washington, the cap-and-trade programmes in California and Washington, as well as the state-level SAF tax credit in Illinois. These initiatives are mainly aimed at attracting investment and stimulating local economic growth while simultaneously driving decarbonization in those states.

2.2 Key actions to take

The regulatory environment and market dynamics are significantly different from Europe, and stakeholders are mainly focused on making SAF scaling profitable, while acknowledging the emerging demand as well. The 10 most relevant topics discussed by public and private stakeholders in the US, which partly coincide with European focus areas, fall into the same three categories: collaboration, finance and policy.

FIGURE 7: **Results from the US SAF Pulse survey among aviation and energy industry stakeholders (33 participants)**

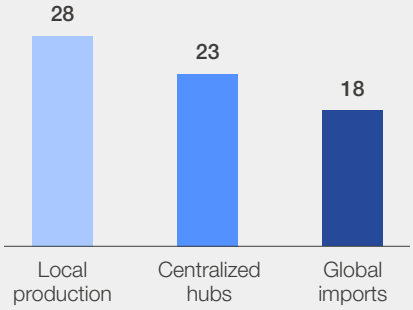
US SAF Pulse survey among aviation and energy industry stakeholders

Participants: 33 private and public-sector organizations

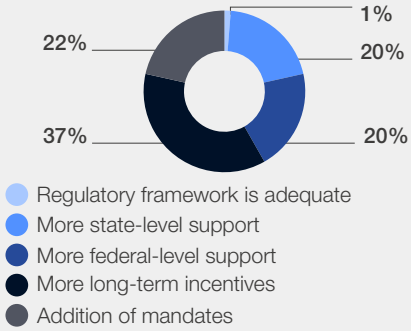
Note: Figures on bar charts may reflect the number of responses to each entry rather than the number of participants as in some cases respondents could vote for more than one option.

Source: Kearney and Airports of Tomorrow

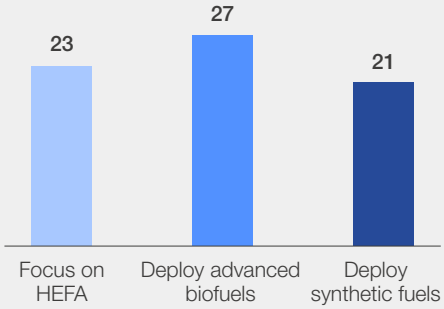
Which SAF supply options will be relevant for the US in 2030?



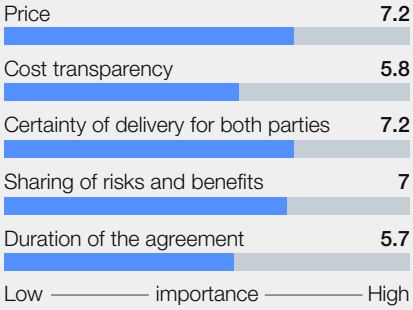
Are current policies adequate to support SAF scaling or which additions do we need?



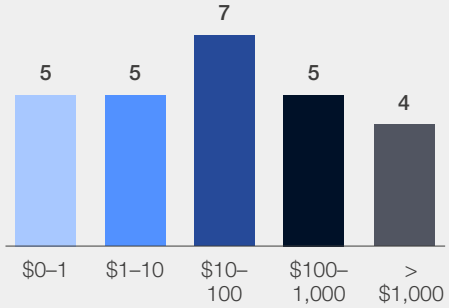
What are key technology strategies to scale SAF until 2030?



Which aspects are most important in negotiating SAF supply contracts?



How much would your organization co-invest in a SAF production facility? ($ million)



2.2.1 Collaboration

1. Collaborate on national SAF supply strategy

Key stakeholder groups: Airlines, airports, SAF producers, governments and regulators, OEMs

Successful scaling requires robust collaboration across industries to share risk and align on supply and demand. Stakeholders in the region expect that the majority of SAF will be produced in localized and centralized sites within the US (see Figure 7).

Exploring broader and more integrated public–private partnerships is crucial for risk-sharing as well, ensuring demand certainty and facilitating cost-improvement participation. One de-risking option in this context is to use tax credits and loan guarantees to make investments in SAF production profitable across the entire value chain.

Supply bottlenecks can be addressed through collaboration along the value chain, while also aligning on and communicating additional government actions required to enable rapid SAF scaling. Furthermore, airlines and airports are evaluating the role of offtakers and are looking into the option of syndicated offtake agreements. The formulation of regional plans can secure demand signals by aggregating SAF buyers in alliances and by implementing dynamic airport charges.

2. Provide transparent and traceable SAF properties

Key stakeholder groups: Airports, SAF producers, OEMs, service providers

A fully certified SAF mixture exhibiting reproducible quality within acceptable limits is vital for ensuring safe aircraft operations. The supplied fuel must therefore comply with airport and OEM standards, while blending and certification is ideally performed directly at the production site.

Relevant fuel properties must be shared to ensure safe engine and aircraft operation. SAF producers should enable transparent tracking of environmental benefits by providing relevant key performance indicators (KPIs), including feedstock types and sustainability, technology pathway, production location and total production carbon footprint.

Aircraft and engine OEMs must ensure compatibility of different SAF types with all produced aircraft systems. In doing so, collaboration between OEMs is key to ensuring similar engine performance for SAF and fossil fuels. Additionally, manufacturers are working towards adapting their technologies to be compatible with new SAF types and higher blend ratios (e.g. up to 100% SAF).

3. Commit to tangible risk-sharing SAF contracts

Key stakeholder groups: Airlines, airports, SAF producers, governments and regulators, service providers, corporate travellers

Long-term offtake agreements are critical for investment certainty and industry scaling, enabling cost reductions through economies of scale and technology innovation. When negotiating such contracts, stakeholders put emphasis on price, certainty of delivery and risk- and benefit-sharing (see Figure 7). Book and claim systems are one tool that can enable these offtakes, and their trustworthiness to external stakeholders (e.g. NGOs, governments) is vital for their wide adoption.

While airlines and OEMs have already started sending significant demand signals to the market, more action is required, especially from customers, airports, governments and traditional oil and gas companies.

The transition of SAF strategies from global pledges and promises to specific supply initiatives, including confirmed annual supply volumes and risk- and benefit-sharing mechanisms, is an important first step to take. In doing so, reliable and credible offtake agreements with SAF suppliers are needed, committing to the green premium, but balancing incentives and partner contributions.

Transparent "cost plus" schemes can be effective tools in developing long-term contracts, including risk- and benefit-sharing. This should comprise limiting margins on SAF vs. fossil-based jet fuel and ensuring at least a partial pass-through of future SAF cost improvements to offtakers. Furthermore, stakeholders should include clear SAF targets in their sustainability agendas and roadmaps (e.g. consumption targets for airlines and supply targets for SAF producers).

Service providers can have multiple roles in facilitating and enabling these partnerships. They can act as matchmakers, bringing together investors and governments as well as industry representatives, and they can suggest appropriate partnership structures to ensure each party profits from the collaboration.

4. Build infrastructure for SAF roll-out

Key stakeholder groups: Airports, SAF producers, service providers

Most infrastructure needed for the distribution of drop-in SAF is already available but might need some adaptations, as is the case for on-site blending at existing refineries. At the same time, refineries are underused, and co-processing of bio-feedstocks could be an attractive option to quickly increase SAF production.

Ideally, new production sites should be located close to existing infrastructure, with facilitated access being especially crucial for smaller producers to help support rapid scaling. Where investment is required to develop new infrastructure and reduce bottlenecks in the system, collaboration between stakeholders (e.g. airports, SAF producers, service providers) is crucial. Airports can play a facilitator role in this, bringing together infrastructure owners and SAF producers by using their key role within the industry.

5. Increase awareness of all advantages of SAF

Key stakeholder groups: Airlines, airports, SAF producers, governments and regulators, OEMs, service providers, corporate travellers

The public sector and the wider public have insufficient knowledge of the importance of SAF and the advantages that come from increasing its supply, making effective awareness-building paramount. This can be done by promoting SAF locally and highlighting the additional environmental and health benefits (e.g. better air quality) alongside the economic opportunities. In doing so, connecting climate change concerns from consumers with the positive impact of SAF and developing academic research (e.g. air-quality studies) can improve public opinion.

Engaging with the public is also important to attract young talent to the aviation industry and contribute to its decarbonization. Partnerships between stakeholders will allow communication to be designed with one unified voice, which is particularly relevant when working with regulators on the creation of suitable SAF standards and policies.

2.2.2 Finance

1. Invest in SAF research and development to improve cost and sustainability

Key stakeholder groups: Airlines, SAF producers, OEMs

The US is well positioned to lead in SAF production, and funding new technologies will strengthen its competitive position further. The industry estimates that deploying advanced biofuels as well as focusing on HEFA are key to increasing SAF production by 2030 (see Figure 7).

SAF producers are focusing on designing research and development roadmaps and efficiently moving on to production and scaling. To do so, the research should ideally focus on improving cost and sustainability, while also improving versatility and the availability of sustainable feedstocks. The collaboration with other stakeholders should be structured efficiently and partners identified based on clearly defined partnership criteria.

Required investment volumes to support early-stage start-ups and pilot ("first of a kind", or FOAK) plants are low compared to building an industrial-scale production site. However, these early investments can have a more pivotal effect, as the higher risk at these stages often hinders access to capital. Some corporate travellers, airlines and airports have started exploring disruptive/riskier technologies (e.g. PtL pathways) by using their internally available funds and promoting innovation. In doing so, they use their network to share investment risk, advance disruptive technologies and secure future cost-competitive SAF supplies.

2. Encourage investment to scale SAF supply

Key stakeholder groups: Airlines, SAF producers, governments and regulators, OEMs, service providers

Low engagement of financial institutions poses a significant hurdle for scaling SAF supply. Enhancing credibility and credit ratings is essential for unlocking private financing. This becomes crucial when considering that alternatives, such as renewable diesel, remain more attractive investment opportunities. It is thus paramount to signal to the financial sector that investing in SAF, aside from its clear decarbonization benefits, is a lucrative business opportunity.

When it comes to reducing CO_2 emissions in the drive towards net zero, time is key, and the most efficient way to deploy resources to quickly reduce emissions should be chosen. Presenting SAF as a profitable investment avenue involves articulating the business case for SAF and emphasizing its potential for robust financial returns. In addition, stakeholders within the ecosystem are looking to support scaling through investments as well and are willing to commit significant funds (see Figure 7).

Airlines and OEMs are looking for partnerships with SAF producers and are willing to contribute to development costs, share technical knowledge and/or co-invest CapEx. Financial institutions can create blended finance options for new SAF projects, increasing pricing attractiveness for SAF credits. Partnering with SAF producers, customers and governments can help create a shared vision for scaling SAF and de-risking related investments.

Streamlining bureaucracy for SAF projects and facilitating the conversion of existing facilities to produce SAF, as well as the construction of new plants, are key steps for governments to take. Additionally, they can facilitate access to publicly guaranteed funds and land acquisition for feedstock suppliers. Other support options for the public sector are to provide long-term incentives, grant programmes, loan guarantees and targeted SAF incentives.

2.2.3 Policy

1. Increase public-sector engagement

Key stakeholder groups: Governments and regulators

Public-sector involvement is indispensable for fostering policy advocacy, regulatory support and an overall enabling environment for SAF. Policy is an important lever driving demand and supply, and industry players see that both incentives and mandates can play a role (see Figure 7). Some areas in need of increased policy attention are the incentives for using more versatile and sustainable biomass feedstocks (e.g. agricultural waste) and the improvement of the LCFS through, for instance, the inclusion of aviation-specific mandates.

In addition to federal engagement, state-level incentives can promote local production, which entails lower value chain complexity and local buy-in, effectively acting as a ramp-up mechanism towards centralized SAF hubs. A possible component of this can be the introduction of local airport-specific incentives, encouraging airlines to increase SAF usage (e.g. discounts on landing fees).

2. Define SAF carbon accounting standards

Key stakeholder groups: Airports, airlines, governments and regulators

Clear carbon accounting rules for SAF are needed to provide clarity and direction to the industry and to attract corporate customers especially to long-term offtakes. Working with international organizations can help reinforce SAF terminology and clarify technical aspects. The resulting guidelines should also include information on KPI reporting and feedstock eligibility.

Airlines in particular are supporting the implementation of a book and claim system to facilitate SAF uptake through collaboration with corporate buyers. The latter can use book and claim to embed SAF into their corporate travel programmes, and they can develop an internal carbon pricing mechanism to finance the green premium of SAF.

3. Extend the duration and availability of incentives

Key stakeholder groups: Airports, governments and regulators

One key regulatory concern in the US revolves around the duration of the existing incentives and whether they will remain active long enough to substantiate the business case for long-term investments spanning approximately 30 years. Stakeholders particularly regard the event of a political power shift and a potential subsequent deprioritization of sustainability-related topics as a key barrier.

Governments can address these concerns by developing a longer-term tax credit incentive plan for producers and offtakers. This could be based on current incentives and should be designed to effectively support SAF ramp-up, including emerging disruptive technologies. Additionally, subsidies to support the green premium cost for airlines should be evaluated to ensure their continued competitiveness while increasing SAF usage. Policy-makers can work with industry on implementing revenue certainty mechanisms to bridge the cost gap between conventional jet fuel and SAF. The impact of proposed incentives and policies on the long-term SAF price should be quantified and analysed to evaluate their effectiveness and prioritize their implementation.

3 Scaling SAF for the Middle East

SAF initiatives are emerging but not yet supported by robust regulation. Interest in green energy and greening existing refineries will continue.

3.1 Middle East situation and challenges

The Middle East has traditionally been a key producer of fossil fuels, as almost half of global proven oil reserves are located in the region.[39] Additionally, its strategic location between Europe and Asia has made it an ideal aviation hub. In recent years, the Middle East has seen increased interest and the beginning of a shift towards green energy and hydrogen production.

To this end, the United Arab Emirates (UAE) has recently included significant H_2 plans in its revised energy strategy, aiming for 1.4 Mt of H_2 production in 2030,[40] while Oman has announced plans to produce at least 1 Mt of H_2 annually by that time.[41]

Saudi Arabia aims to produce 2.9 Mt by 2030, focusing on blue H_2, requiring carbon capture and storage technology.[42]

At the same time, activities related to SAF have so far been relatively small in scale as local actors focus on LCAF and co-processing solutions to quickly reduce CO_2 emissions from fossil fuel refining. Notable exceptions are the recent agreement between the UAE and Shell, which will represent the first blended SAF supply through Dubai International Airport,[43] and Abu Dhabi National Oil Company (Adnoc), which is set to provide SAF to Abu Dhabi International Airport.[44]

3.2 Key actions to take

Regulation is in its infancy, and the region has yet to show strong commitment to taking advantage of its favourable position for SAF production. However, stakeholders in the region are already actively discussing action areas to enable SAF scaling, five of which are especially relevant: 1) cross-industry collaboration; 2) greening existing refineries; 3) PtL deployment; 4) government and regulator engagement; and 5) public awareness and education.

FIGURE 8: **Results from the UAE SAF Pulse survey among aviation and energy industry stakeholders (35 participants)**

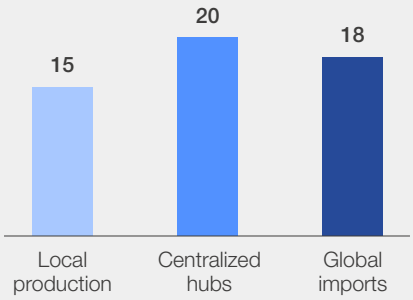
UAE SAF Pulse survey among aviation and energy industry stakeholders

Participants: 35 private and public-sector organizations

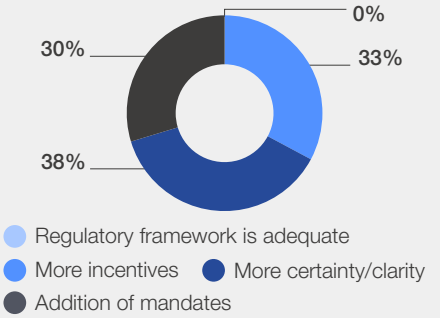
Note: Figures on bar charts may reflect the number of responses to each entry rather than the number of participants as in some cases respondents could vote for more than one option.

Source: Kearney and Airports of Tomorrow

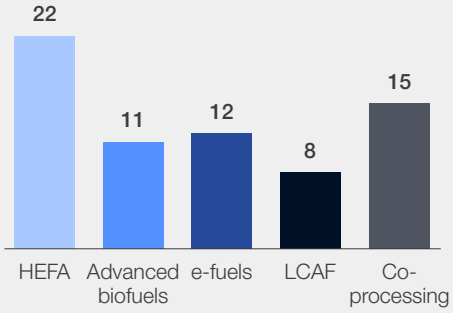
Which SAF supply options will be relevant for the UAE in 2030?



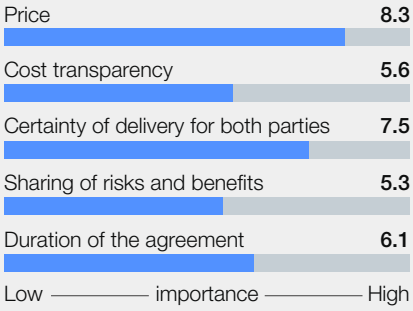
Are current policies adequate to support SAF scaling or which additions do we need?



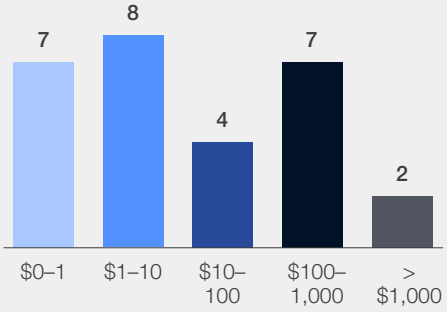
What are key technology strategies to scale SAF until 2030?



Which aspects are most important in negotiating SAF supply contracts?



How much would your organization co-invest in a SAF production facility? ($ million)



3.2.1 Cross-industry collaboration

Key stakeholder groups: Airlines, airports, SAF producers, governments and regulators, OEMs, service providers, corporate travellers

The region already exhibits close integration between the energy and aviation industries, which can be used to drive SAF supply, estimated by the industry to be mostly regional (see Figure 8). New cooperations should include stakeholder groups beyond producers and airlines to de-risk the required investments. When structuring long-term offtake agreements, stakeholders in the region tend to focus on price first, while certainty of delivery and duration of the agreement are also important (see Figure 8).

Airports and seaports can play a leading role in building production hubs in the Gulf region by pooling demand and infrastructure investments. Commitments to hydrogen infrastructure may in this context encourage additional SAF production. Voluntary initiatives will be necessary even when government regulations are passed in the future, as governments will likely not be able to provide all the support needed to scale up the sector themselves.

Transparent accounting and reporting of SAF usage while decoupling physical and environmental properties (e.g. book and claim) is regarded as vital for the region and will require close collaboration as well. Corporate travellers aim to offset their Scope 3 emissions in this way and potentially contribute significantly to covering the green premium.

3.2.2 Improving efficiency in existing refineries

Key stakeholder groups: SAF producers, service providers

Existing refineries in the region have multiple options to quickly reduce their emissions while in parallel evaluating options for dedicated SAF facilities. Co-processing is considered a cost-effective, near-term solution for scaling SAF production in the region (see Figure 8). LCAF, which is based on emission reduction in the production of conventional fossil fuels (e.g. carbon capture and storage), may be another temporary solution. However, LCAF would require additional regulatory certainty and awareness, as it is currently not certified and cannot be used to offset emissions. Refinery owners and operators should evaluate both of these options and their benefits when designing their decarbonization journeys.

3.2.3 Power-to-liquid deployment

Key stakeholder groups: Airlines, SAF producers, governments and regulators

The Middle East is well positioned to produce PtL due to the potential for cheap renewable electricity production and will mainly target international markets willing to pay the additional premium.

However, a clear definition of electrofuels (or e-fuels) is still lacking, as questions, especially about eligible carbon sources, remain. Once defined, accessing these likely scarce sources is vital, and the region has several options it can explore (e.g. off-gas, direct air capture, point sources, algae). PtL SAF also faces competition in the merit order of H_2 uses, likely placing it lower compared to established applications, such as ammonia or methanol production. Investments in this technology will thus remain riskier until regulatory certainty is provided by governments.

The industry can advance PtL deployment by collaborating to define an appropriate business case and create more incentives for technology innovation. It is likely that the region will adopt a fast-follower role as in the past and deploy SAF technology rapidly once it has been developed and proven elsewhere.

3.2.4 Government and regulator engagement

Key stakeholder groups: Governments and regulators

The Gulf region is currently lacking major governmental or regulatory engagement on SAF, which is reflected in stakeholders looking for more support overall (see Figure 8). An exception is the UAE, which, supported by the World Economic Forum, published an initial roadmap for scaling up PtL. While some national policies are being developed, advocacy and collaboration for aviation is needed. Besides providing appropriate financial support, this should also include the development of clear, transparent SAF accounting and reporting standards.

Governments can use their position to address these regulatory challenges quickly, starting by clearly defining e-fuel standards and introducing incentives and/or mandates, drawing parallels with successful EU standards for diesel fuel. SAF producers can encourage public-sector interest by leading the way, constructing the first SAF production sites and demonstrating their strategic relevance for the region.

3.2.5 Public awareness and education

Key stakeholder groups: Airlines, airports, SAF producers, governments and regulators, OEMs, corporate travellers

A key enabler for SAF adoption is a two-pronged approach that combines engaging stakeholders through education with public awareness efforts to secure support from governments and the wider public. Depending on the target audience, different stakeholders are better positioned to do so. Airports and airlines, for instance, are naturally closer to passengers and can thus easily engage them.

To structure communications effectively, target audiences should be well understood and messages tailored accordingly. While general information may be needed for passengers, more specific information will be useful for governments and regulators.

For example, passengers do not necessarily need to know that the aircraft is operating with specific SAF blends; however, governments and operators have an inherent responsibility to know where the SAF has come from. Furthermore, where book and claim systems are used, operators have a right to access data for tracking and reporting purposes. Lastly, stakeholders have an incentive to educate industry peers, competitors and policy-makers. If done in the right way, this can contribute to a change in customer behaviour and convince airlines and their passengers to own part of the green premium. Potentially of even more importance, this will assist in raising awareness with regulators to support sector decarbonization overall.

Conclusion: What will it take to scale SAF globally?

SAF deployment needs rapid technology adoption, and net-zero corridors will likely emerge that connect global production hubs to demand centres. Collaboration, regulation, incentives and accounting standards are crucial.

Rapid technology deployment

SAF has been identified as the major decarbonization solution for the aviation industry, yet current project announcements will cover only around a third of likely SAF demand in 2030. Reaching these ambitious SAF scaling targets requires rapid deployment of available technologies, especially when considering average project durations from inception to operation. Additionally, efforts to research and develop advanced biofuel and synthetic fuel production should be increased to enable continued scaling towards 2050 at competitive prices and without feedstock limitations.

Net-zero corridors

Each technology pathway requires different local conditions to ensure optimal and cost-effective SAF production. Based on feedstock availability, existing infrastructure and cheaply available renewable energy, several key regions are well suited for centralized SAF production to meet global demand. The subsequent establishment of net-zero corridors between these production centres and the world's supply hubs is very likely and will mirror current international fuel supply chains.

Global book and claim systems may be launched to detach the physical and environmental properties of SAF and effectively avoid costly and inefficient transportation. This, however, relies on their credibility, transparency and widespread adoption by stakeholders across the value chain. Also, they will naturally become less relevant over time, as the global share of SAF production compared to fossil fuels increases.

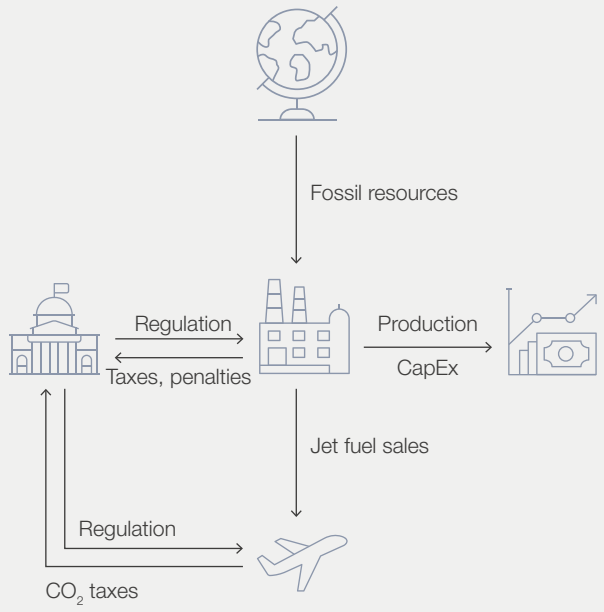
Partnerships and collaboration

Partnerships and collaboration have been shown to be a key success factor in deploying SAF globally. While all aviation sector players have their distinct motivations and goals, working together will help to address many of the current challenges holding back SAF scaling. Public–private partnerships can enable risk-sharing for investors, providing long-term certainty of demand and cost improvement participation for all partners, while ensuring security of supply and sector decarbonization to governments (see Figure 9).

Making capital available for these new technologies will require the development of innovative new financial products. These may include blended finance options, revenue assurance mechanisms, contracts for difference or regional and airport-level incentives. While significant capital is required to construct industrial-scale production sites, much less funding is needed in the early stages of technology development. Some companies with limited funds thus support SAF scaling by focusing on helping early-stage companies or projects. These cases tend to be riskier, meaning that acquiring financial support through conventional means is more challenging. In doing so, companies and projects can overcome the typical early-stage "valley of death", prove their technology and drive SAF production after securing additional traditional funding. Early investors can profit from this through preferred access to SAF with favourable conditions.

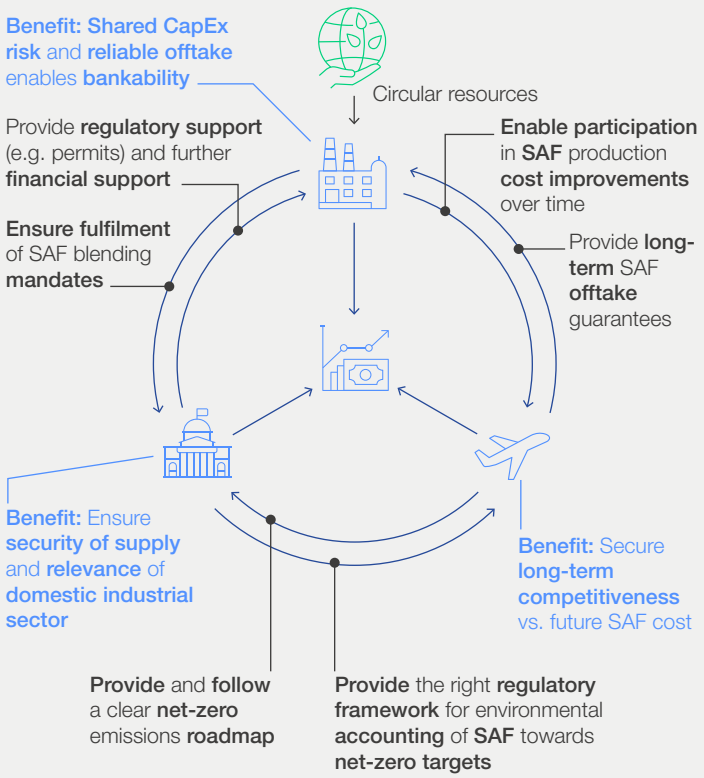
FIGURE 9. **Jet fuel supplier interactions tend to be transactional today – a possible future public–private collaboration would entail close partnering between stakeholders to help each other reach their SAF goals**

Current global ecosystem interactions (simplified)



Source: Kearney and Airports of Tomorrow

Favourable alternative picture public–private collaboration



Regulation and incentives

People have got used to cheap fossil fuel prices over recent decades. It is easy to forget that this is due to the negative externalities (e.g. environmental pollution, global warming) having so far not been factored into the cost. Adopting sustainable aviation fuels will consequently show the true cost of fuel consumption, which will be inherently more expensive in the beginning, as society can no longer "borrow money" from the planet.

The free market by itself will not drive a rapid adoption of SAF under these circumstances, making regulation and policy essential in creating the global SAF market and driving demand. While regions representing 75% of global fuel supply have already passed or are actively discussing appropriate regulation, ambition varies significantly and much remains to be done.

The available regulatory tools can broadly be categorized into: 1) SAF mandates requiring a specific SAF blend in a regulated market; 2) taxation of carbon emissions, effectively pricing in negative externalities of fossil fuels; and 3) financial incentives supporting SAF production until it matures and becomes cost competitive with fossil fuels based on other regulatory measures.

A key aspect in structuring regional regulations is to pursue harmonization and alignment globally to avoid regional disparities, potentially leading to carbon leakage towards less regulated countries. Global collaboration between governments is thus highly recommended to enable efficient SAF scaling and a successful transition towards a clean and sustainable aviation sector.

Accounting standardization and marketplace

A reliable and standardized book and claim system stands as a critical enabler for ensuring the smooth deployment and scale-up of SAF. Such a system serves as the bedrock for tracking, verifying and accounting for the production, distribution and use of SAF across various stakeholders and supply chains. This will have to be underpinned by aligned and transparent accounting mechanisms to accurately trace the SAF throughout its life cycle, from production to consumption.

The trading of SAF will facilitate the creation of a global SAF marketplace and help close the spread between bid and ask prices. This, together with higher liquidity of the SAF market, will encourage greater investment in SAF production.

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