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Can South Korea's Aviation Industry Pivot to Green Skies?

By addressing challenges and leveraging opportunities in its domestic sustainable aviation fuel (SAF) industry, South Korea could lead global aviation decarbonization efforts

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Key Findings

South Korea, the largest exporter in the global jet fuel market, implemented a sustainable aviation fuel (SAF) mandate in August 2024. The mandate requires a 1% SAF blend for international flights by 2027 to drive aviation decarbonization, which accounts for 2-3% of global greenhouse gas (GHG) emissions.

The International Air Transport Association (IATA) projects that 449 billion liters of SAF will be needed by 2050 to achieve net-zero emissions in the aviation sector. The market value is expected to be around US$45 billion in 2030, prompting many countries to adopt SAF mandates.

While SAF offers a promising path toward decarbonization with economic benefits, a cautious approach is needed to address various challenges associated with using unsustainable feedstocks and production technologies. There are related sustainability concerns, including deforestation, biodiversity loss, water scarcity, competition with food uses, and land-use emissions that may exceed the impacts of fossil fuels.

South Korea, with its advanced recycling system, including an 86% waste recycling rate and ranking second in the Organization for Economic Cooperation and Development (OECD) for municipal waste recycling, has significant potential to lead SAF production and its supply chain.

Executive Summary

The aviation industry is one of the hard-to-abate sectors for addressing climate change, accounting for around 2-3%[1, 2] of global greenhouse gas (GHG) emissions. Passenger numbers are projected to reach 10 billion globally by 2050.[3] Carbon emissions from 2021 to 2050 on a business-as-usual scenario will likely reach 21.2 gigatonnes of carbon dioxide (CO_2)[4], marking around 13% compound annual growth rate (CAGR).[5]

Given its rapid expansion in market size and increase in carbon emissions, the air transport sector should have a decarbonization pathway. However, due to the complexity of international aviation involving multiple countries, companies, and stakeholders, this industry has been excluded from the Paris Agreement and decarbonization has lagged. Accordingly, the aviation industry is looking for ways to reduce GHG emissions in the shorter term while developing more sustainable long-term solutions. Sustainable aviation fuel (SAF) could decrease emissions from air travel.

SAF is an innovative solution for decarbonizing the aviation sector by utilizing alternative feedstocks such as waste fats, oils, and grease (FOG), municipal solid waste (MSW), food waste, algae, and photosynthetic organisms. It can reduce CO_2 emissions by up to 80% compared to traditional jet fuel. SAF offers a drop-in solution for decarbonizing aviation, requiring minimal aircraft or infrastructure modifications, with current blends allowing up to 50% SAF and fossil jet fuel. The aviation industry aims for full SAF compatibility (100% blend) by 2030.

Despite its environmental benefits, SAF faces challenges, including limited feedstock availability, high production costs (two to five times higher than fossil jet fuel), and technological limitations. The dominant production process, hydroprocessed esters and fatty acids (HEFA), relies on feedstocks like used cooking oil and animal fats, which are in short supply.

This feedstock scarcity and unaffordability risks a shift towards first-generation feedstocks (such as soybean and palm oil), which are cheaper and more readily available but are associated with sustainability concerns, including deforestation, biodiversity loss, water scarcity, competition with food uses, and land-use emissions that may exceed fossil fuel impacts. Additionally, not all SAFs achieve the same degree of carbon reduction. Some production methods have higher carbon footprints than others.

Despite its challenges, limitations, and the absence of viable near-term technological alternatives, many countries and global aviation leaders are eager to spearhead advancements in the SAF industry. The International Air Transport Association (IATA) estimated that 449 billion liters of SAF

[1] IEA. Website.
[2] Sustainabilitybynumbers. How much does aviation contribute to climate change? How will this change in the future? 26 September 2023.
[3] IATA. Net Zero Carbon 2050 Resolution.
[4] IATA. Net Zero Carbon 2050 Resolution.
[5] IEEFA. Sustainable aviation fuel: Not a panacea, but likely helpful if key issues are resolved. August 2024.

will be required by 2050[6] to achieve net-zero emissions, representing a CAGR of 17.5% compared to the 2025 level.

The SAF market value is projected to surge from US$0.6 billion in 2022 to around US$45 billion[7] in 2030, a nearly 75-fold increase. With global carbon regulations in aviation tightening and major countries rolling out SAF mandates, demand could continue its upward trajectory.

Motivated to safeguard its leading position in the jet fuel industry and accelerate decarbonization in aviation, South Korea implemented a SAF mandate in August 2024. The mandate requires all departing international flights from the country to use at least 1% SAF starting in 2027.[8]

South Korea was the largest jet fuel exporter in the world, selling around 92 million barrels[9] in 2023, accounting for about 4% of the global jet fuel trade. The country's petroleum products, including jet fuel, comprise around 9%[10, 11] of total South Korean annual exports, ranking third[12] behind semiconductors and automobiles.

The aviation industry recorded exceedingly high carbon intensity, with Korean Air[13], the country's flagship carrier, ranked among the top large-cap companies in South Korea with the highest carbon intensity. Without some action, the country will remain a significant source of aviation sector emissions worldwide. Consequently, South Korean jet fuel refiners could adopt SAF to reduce emissions.

South Korea, with its advanced recycling system, including an 86% waste recycling rate and ranking second in the Organization for Economic Cooperation and Development (OECD) for municipal waste recycling, has significant potential to lead SAF production and its supply chain. The timely development of a domestic SAF industry, while addressing challenges and risks, is crucial for leveraging opportunities and achieving a greener aviation future.

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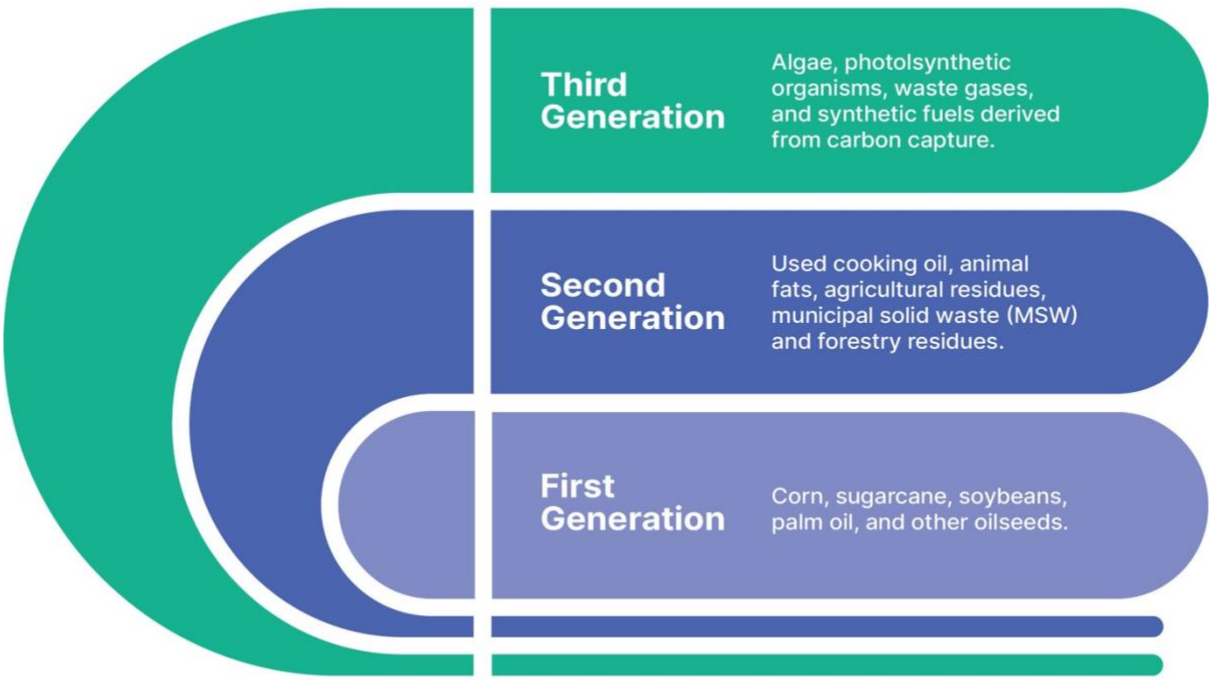
[6] IATA. Net zero 2050: sustainable aviation fuels. May 2024. Page 04.
[7] The calculation was based on the average SAF price of US$2,437/Mt in 2022 and projected SAF demand of around 18.35 Mt in 2030.
[8] Reuters. South Korea plans mix of sustainable aviation fuel for international fights from 2027. 30 August 2024.
[9] Petronet. Website.
[10] Korea Petroleum Association. Website.
[11] Yonhap. Trade deficit in 2022 recorded at 47.2 billion dollars, largest in history. 01 January 2022.
[12] Maeil Economic Daily. Korean refiners in uproar as half of US jet fuel imports come from Korea, threatening exports. 24 October 2022.
[13] FutureChosun. The average greenhouse gas emissions of the top 30 companies are 4.26 million tons, with Korean Air ranking first in intensity. 13 August 2024.

An Overview of Sustainable Aviation Fuel

SAF is a liquid fuel made from waste FOG, MSW (second-generation feedstocks), and food waste, algae, and photosynthetic organisms (third-generation feedstocks), which can reduce CO_2 emissions up to 80% compared with traditionally derived jet fuel from oil (Figure 1).[14, 15]

Figure 1: SAF Feedstocks



Source: IEEFA.

SAF potentially offers a drop-in[16] solution for advancing the decarbonization of the aviation sector. Chemically similar to traditional jet fuel, SAF requires minimal aircraft or infrastructure modifications. Based on current certification processes, commercial flights can fly with a blend of up to 50% SAF and fossil jet fuel. The industry is targeting full SAF compatibility (100% blend) by 2030.[17]

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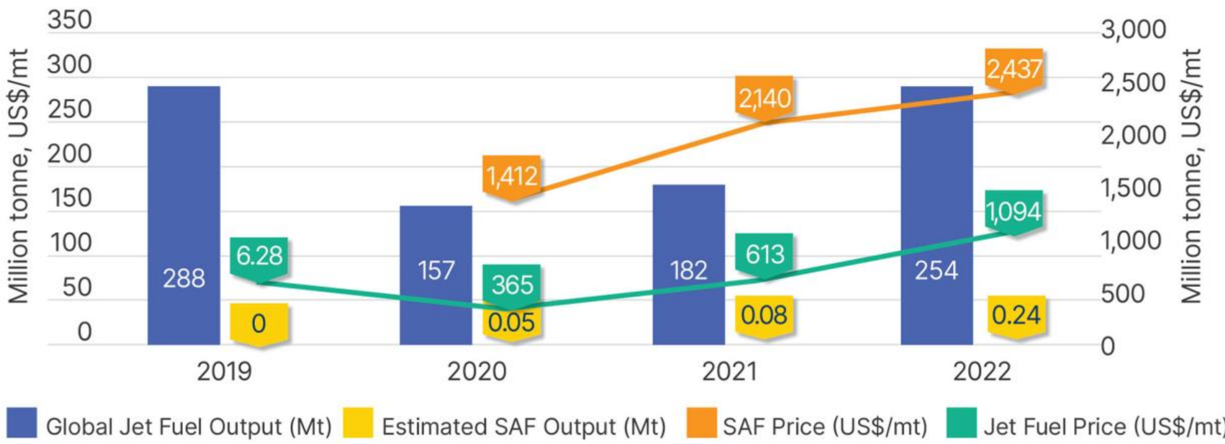
[14] IATA. Net zero 2050: sustainable aviation fuels factsheet. May 2024.
[15] SAF produced from first-generation feedstocks, such as food-grade fats and oils is not widely accepted as sustainable due to the land usage and deforestation issues, and EU ETS allows only SAF made from second and third-generation feedstocks under the Renewable Energy Directives.
[16] SAF can be used as a direct replacement for traditional fossil jet fuel. It does not require any changes to existing aircraft or infrastructure (like airports and fuel tanks).
[17] Aerospace. 100% SAF - Technical challenges flying a no-blend sustainable aviation fuel. 03 October 2023.

SAF is not a fully carbon-neutral solution as CO_2 is still released when the fuel is burned. However, since its production process relies on FOG or MSW, SAF could help reduce the overall emissions from the production-use lifecycle by 50% to 80%.

Despite its environmental benefits, the SAF industry is in its infancy, with global production at a mere 0.1%[18] of fossil jet fuel and a price approximately two to five times higher, mainly due to limited feedstock availability (Figure 2).

Figure 2: SAF vs Jet Fuel Output and Price



Note: SAF price published by Platts is based on cost-plus methodology.
Source: IATA.

Challenges and Limitations

The transition to SAF faces multiple challenges that hinder its widespread adoption. This results in supply falling far short of demand, limiting the potential for carbon abatement. Industry targets are currently aiming for an annual contribution of SAF in use volumes of only 1%, indicating the scale of the challenges faced.

The primary barriers to SAF adoption are limited feedstock availability, difficulties of pre-treatment[19], and immature technology for scalable production. Consequently, SAF typically costs two to five times more than conventional jet fuel.

[18] SAF production in 2022 was estimated at around 0.24 million tonnes (Mt), while jet fuel was at 254 Mt. IATA. Air Passenger Market Analysis. 01 September 2023.
[19] The pre-treatment of SAF feedstocks is costly and complex, requiring the removal of contaminants, consistent quality control, and hydrogenation, which are made challenging by the variability of feedstock types and the immature scalability of current technologies.

Feedstock Constraints and Production Technology

The HEFA process currently dominates SAF production due to its maturity and commercial availability.[20] Despite its prevalence, HEFA can only supply around 10% of global jet fuel use[21] as it relies heavily on specific feedstocks like used cooking oil, animal fats, and vegetable oil, which are in limited supply and require costly pre-treatment.

This feedstock scarcity and unaffordability risks a shift towards first-generation feedstocks (such as soybean and palm oil), which are cheaper and more readily available but are associated with sustainability concerns, including deforestation, biodiversity loss, water scarcity, competition with food uses[22], and land-use emissions that may exceed fossil fuel impacts (Figure 3).[23]

Figure 3: SAF and Feedstock Price Comparison

Source: Industry.

Although many countries and SAF producers have shifted to more sustainable second-generation feedstocks, around half of the global SAF production still relies on first-generation feedstocks, such as food-grade fats and oils.

Regulations vary by country. The European Union's (EU) Renewable Energy Directive II (RED II) is phasing out high indirect land-use change (ILUC) feedstocks like palm oil by 2030, while the U.S.

[20] Around 82%. Rhodium Group. Sustainable Aviation Fuels: The Key to Decarbonizing Aviation. 07 December 2022.
[21] SAF Investor. How is Sustainable Aviation Fuel (HEFA SAF) made? 17 February 2023.
[22] This could divert vegetable oils from human consumption and spur rising food prices. SAF Investor. How is Sustainable Aviation Fuel (HEFA SAF) made? 17 February 2023.
[23] SAF Investor. Is it too good to be true? Is it all just greenwashing?

Renewable Fuel Standard (RFS) allows first-generation feedstocks if they meet specific GHG reduction requirements.

Brazil, Australia, Indonesia, Malaysia, and South Korea also allow first-generation feedstocks under their own frameworks with mixed levels of restriction and sustainability criteria.

Table 1: Regulatory Overview of First-Generation Feedstock Use in SAF by Region

Country	Regulations	Detail
European Union	EU Renewable Energy Directive II (RED II)	Allows first-generation feedstock under certain conditions.
		The feedstock must not contribute to deforestation or biodiversity loss.
		Type of crops that can be used is restricted.
		Land conversion associated with feedstock production is scrutinized.
		High indirect land-use change (ILUC) risk feedstock, such as palm oil, are being phased out by 2030.
United States	Renewable Fuel Standard (RFS)	Allows first-generation feedstocks if it meets lifecycle greenhouse gas reduction requirements.
		The U.S. Department of Agriculture (USDA) has sustainability criteria for SAF production, particularly from feedstocks like corn or soy, to avoid negative impacts on food supplies and land use.
Brazil	RenovaBio	Supports SAF production from first-generation feedstocks like sugarcane ethanol, provided it complies with sustainability standards under RenovaBio, the country's national biofuels policy.
Australia	Renewable Energy Act	Allows SAF production from certain first-generation feedstocks like canola and other locally grown oilseeds under sustainability frameworks to reduce the risk of land-use change.
Indonesia and Malaysia	ISPO, MSPO	Both countries produce SAF and biofuels from palm oil, a first-generation feedstock.
		Sustainability certifications, such as Indonesia Sustainable Palm Oil (ISPO) and Malaysian Sustainable Palm Oil (MSPO), which aim to mitigate deforestation risks. However, international acceptance of these standards is mixed.
South Korea	Framework Act on Low Carbon, Green Growth	First-generation feedstocks such as vegetable oils (including canola and palm oil) can be utilized in SAF production. However, their use is subject to sustainability certifications that ensure responsible sourcing and minimal environmental impact.

Source: IEEFA.

Tracking the sourcing of raw materials is crucial for sustainable SAF production and trade. Diverting non-sustainable feedstocks to SAF can result in ethical and environmental issues.

Additionally, not all SAFs achieve the same degree of carbon reduction. Some production methods have higher carbon footprints than others. For example, the co-processing pathway can bolster faster upscale using existing refinery infrastructure. However, the CO_2 reduction rates vary (20-80%) depending on the percentage of sustainable feedstocks used.

Table 2: SAF Production Pathways

Technology	American Society for Testing and Materials (ASTM) Standard	Feedstocks	Advantages	Disadvantages	Maximum Blending Ratio	CO_2 Reduction Rates
Hydro processed Esters & Fatty Acids (HEFA)	ASTM D7566 Annex A2	Used cooking oil, animal fats, vegetable oils	Mature technology, commercially available, can use various feedstocks	Requires significant hydrogen, consumes energy, limited supply of some feedstocks	50%	50–80%
Fischer-Tropsch (FT)	ASTM D7566 Annex A1	Biomass, municipal solid waste (processed), renewable electricity & captured CO_2	Adaptable to various feedstocks, potential for carbon-negative fuels (e-fuels)	More complex technology, under development for large-scale SAF production	50%	60–85%
Co-processing	ASTM D1655	Vegetable oils, waste oils & fats, FT-wax	Leverages existing refinery infrastructure, faster implementation	Limited SAF production volume per blend, may not meet all sustainability goals	10%	20-80%
Alcohol-to-Jet (ATJ)	ASTM D7566	Bio-alcohols (ethanol, iso-butanol)	Potential for lower production costs, diverse feedstock options	Emerging technology, limited commercial availability	50%	50–75%

Source: IEEFA.

Using third-generation feedstocks with carbon capture, utilization, and storage (CCUS) for SAF raises concerns about extending fossil fuel reliance.

CCUS can be costly, ranging from US$35 to US$168 per tonnes.[24] This high cost makes synthetic fuels from captured carbon less competitive than conventional jet fuels.

Additionally, the energy demands of capturing CO_2 lead to increased dependence on fossil fuels, such as natural gas, undermining SAF's net carbon reduction benefits.

Carbon Accounting and Regulatory Challenges

Using unsustainable feedstocks and technologies for SAF production can result in financial consequences once the EU's Carbon Border Adjustment Mechanism (CBAM) or the anticipated U.S. Clean Competition Act (CCA)[25] includes the aviation sector and stricter financial disclosures are required.

The aviation sector is not directly included in the CBAM, but the EU is scrutinizing its carbon footprint. As CBAM undergoes its transitional phase until 2026, discussions are ongoing about expanding its scope by 2030 to cover additional sectors with high carbon leakage, such as aviation.

Furthermore, SAF producers and airlines face complex carbon accounting and monitoring requirements as part of sustainable financial reporting mandates, such as the Corporate Sustainability Reporting Directive (CSRD)[26, 27] and the International Financial Reporting Standards Sustainability Standards (IFRS S2).[28] Reporting has to align with Scope 1 (direct emissions from aircraft operations), Scope 2 (indirect emissions from purchased energy), and Scope 3 (indirect emissions along the supply chain, including fuel production) requirements.

Most incentives for SAF, including the U.S. Inflation Reduction Act (IRA), are contingent on reducing GHG emissions or the carbon intensity of the final product. A life cycle analysis (LCA) evaluates these reductions, assessing GHG emissions across the entire supply chain - from feedstock production to end use. Utilizing non-sustainable feedstocks for SAF production could jeopardize the eligibility for these incentives.[29]

[24] IEEFA. CCS and Blue Hydrogen: Unproven Technology and Financial Risk. 22 July 2024. Page 18.
[25] Upcoming bipartisan carbon tax-related bills, such as the Clean Competition Act (CCA), PROVE IT Act, Foreign Pollution Fee Act, and Market Choice Act, are most likely to be passed. IEEFA. South Korea needs to accelerate renewable energy adoption to fuel Artificial Intelligence (AI) and semiconductor sectors. 10 October 2024.
[26] CDP. Q&A: Corporate Sustainability Reporting Directive (CSRD). May 2021.
[27] This directive enforces stricter reporting requirements and aligns with the EU's Fit for 55 initiatives, aiming for a 55% reduction in emissions by 2030 compared to 1990 levels. European Council for EU. Website.
[28] IFRS. IFRS S2 Climate-related Disclosures.
[29] NREL. Sustainable Aviation Fuel (SAF) State-of-Industry Report: State of SAF Production Process. July 2024. Page 30.

Technological and Infrastructure Constraints

Different SAF production technologies, such as HEFA, Fischer-Tropsch (FT), co-processing, and Alcohol-to-Jet (ATJ), offer varying CO_2 reduction rates, feedstock compatibility, and scalability potential.

Current aviation industry fuel standards restrict blending ratios with conventional fuel to 50%, which limits SAF's emissions reduction capability.

Additionally, SAF's production and distribution infrastructure, including transport to airports, tankage, blending, and retrofitting refueling systems, remains underdeveloped in many countries, adding costs and logistical barriers.

Policy, Public Awareness, and Price Volatility

The regulatory landscape for SAF is still evolving, leading to inconsistent policies and incentives across regions. For instance, the EU Fit for 55 and the U.S. IRA offer differing support, leading to financial uncertainty and constrained investment. Without consolidated international policy frameworks, certain airlines could avoid using airports in countries with stricter SAF mandates and regulations. Airlines that avoid the added SAF cost could gain an advantage over airlines with more sustainable operations.

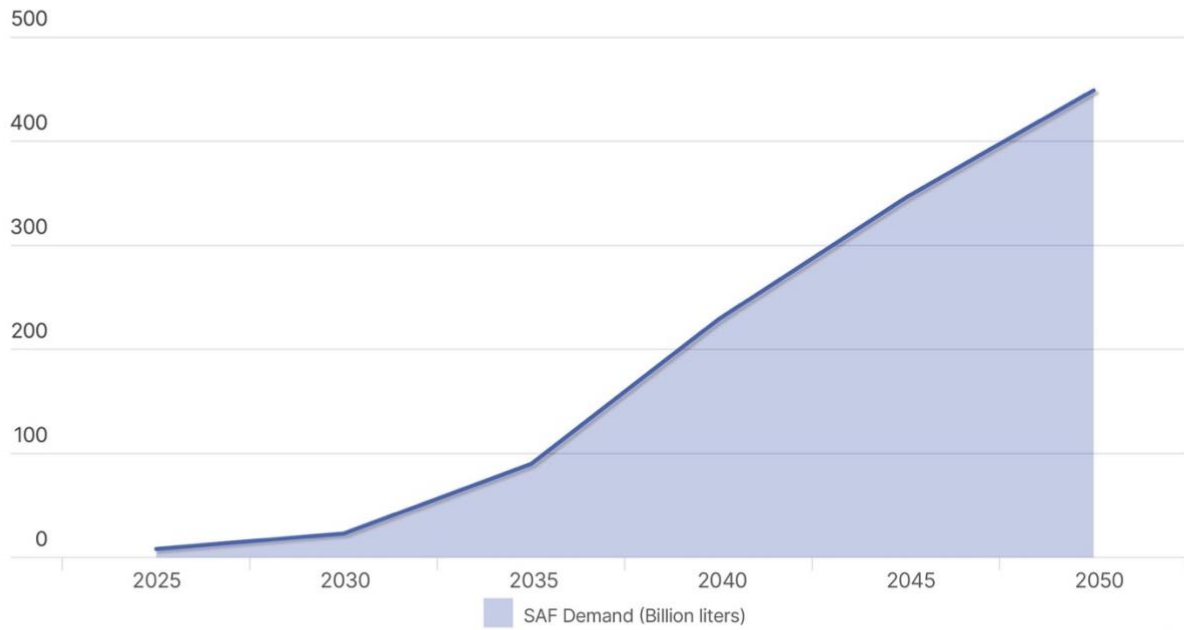
Public perception and awareness also impact SAF demand. While sustainable fuel adoption could help meet climate goals, the potential increase in ticket prices due to SAF's cost might reduce public support, affecting demand and scalability.

Global Race for the US$45 Billion SAF Market

Despite its challenges, limitations, and the absence of viable near-term technological alternatives, many countries and global aviation leaders are eager to spearhead advancements in the SAF industry. The IATA estimated that 449 billion liters of SAF will be required by 2050[30] to achieve net-zero emissions, representing a CAGR of 17.5% compared to the 2025 level.

[30] IATA. Net zero 2050: sustainable aviation fuels. May 2024. Page 04.

Figure 4: SAF Demand Outlook



Source: IATA.

The SAF market value is projected to surge from US$0.6 billion in 2022 to around US$45 billion[31] in 2030, a nearly 75-fold increase.

With global carbon regulations in aviation tightening and major countries rolling out SAF mandates, demand could continue its upward trajectory.

The International Civil Aviation Organization (ICAO), recognized by the Paris Agreement as a specialized agency of the United Nations, launched the Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA) in January 2024 to address decarbonization in aviation. In 2022, ICAO member states agreed to achieve net-zero emissions by 2050 and a 5% reduction by 2030[32] using cleaner energies, including SAF.

CORSIA will be applied to international flights in three phases - two voluntary phases from 2021-2023 and 2024-2026, and a mandatory phase from 2027 onwards. The scheme will be applied to all international flights from 2027 onwards.[33]

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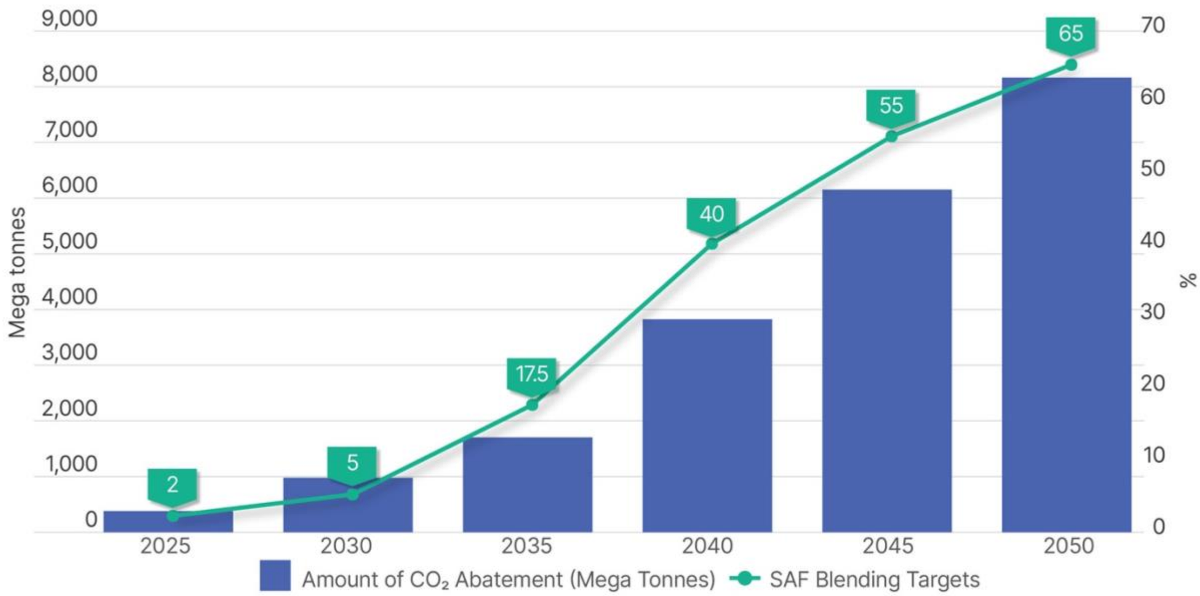
[31] The calculation was based on the average SAF price of US$2,437/Mt in 2022 and projected SAF demand of around 18.35 Mt in 2030.
[32] The CORSIA, adopted by the ICAO in 2016, requires airlines that emit an excessive number of emissions need to buy carbon credits. In 2023, ICAO and its member states agreed to strive to reduce CO_2 emissions in international aviation by 5% by 2030, using cleaner energies. As of 2024, around 126 countries, including South Korea, participated in CORSIA voluntarily. ICAO. Website.
[33] Aviation Benefits Beyond Borders. CORSIA explained.

The EU's Emissions Trading System (ETS) has included the aviation sector since 2012 and mandates that all airlines operating in Europe monitor, report, and verify (MRV) emissions. In June 2023, the EU strengthened its ETS for aviation and phased out free emission allowances. Consequently, all airlines must purchase emission allowances through auctions.

The IATA released its five Net Zero roadmaps[34] in June 2023, outlining a path for the aviation industry to achieve net-zero emissions by 2050. SAF is projected to be the leading contributor (65%) for emissions reduction, followed by electric and hydrogen aviation (13%) (Figure 5).[35]

Figure 5: Milestones Towards Net-Zero in Aviation



Source: IATA.

Due to the slow commercialization and technological development of electric and hydrogen aviation[36], SAF is expected to be the aviation industry's primary decarbonization tool for the next 20 to 30 years. SAF's near-term dominance is likely due to electric limitations on large aircraft and mega-scale hydrogen infrastructure needs.

According to IATA, SAF demand could reach approximately 18.35 million tonnes (Mt) by 2030, up from 240,000 tonnes in 2022.[37] Meanwhile, supply is expected to reach around 7.6 Mt by 2030[38], which underscores a persistent gap between demand and supply.

[34] IATA. Net Zero Roadmaps.
[35] IATA. Our Commitment to Fly Net Zero by 2050.
[36] Electric aviation has zero carbon emissions. However, it is difficult to apply to large aircraft, while hybrid aviation requires significant amounts of green hydrogen and has technological challenges in on-craft storage and conversion.
[37] Reuters. South Korea plans mix of sustainable aviation fuel for international fights from 2027. 30 August 2024.
[38] Based on the moderate scenario of SAF replacement ratio of 2.19% in 2030. ICAO. SAF Projections.

With growing adoption due to national SAF mandates, demand could outstrip supply further. This potential shortage reflects the rising demand within the market.

Jet Fuel Giant, South Korea's Ambition to SAF

Motivated to safeguard its leading position[39] in the jet fuel industry and accelerate decarbonization in aviation, South Korea implemented a SAF mandate in August 2024.

The country rolled out the 1% SAF mandate for all departing international airplanes from 2027.[40] The Ministry of Trade, Industry, and Energy (MOTIE) will establish a task force for SAF deployment and roll out a roadmap by the first half of 2025.[41]

South Korea's SAF mandate was announced as many countries introduced related regulations to avail opportunities in the fast-growing market and address decarbonization in the aviation sector (Table 3).

[39] South Korea was the largest jet fuel exporter in the world, selling around 92 million barrels in 2023, accounting for about 4% of the global jet fuel trade. The country's petroleum products, including jet fuel, comprise around 9% of total South Korean annual exports, ranking third behind semiconductors and automobiles.
[40] Reuters. South Korea plans mix of sustainable aviation fuel for international fights from 2027. 30 August 2024.
[41] Newsis. MOTIE, SAF TF initiation, SAF roadmap will be rolled out in H1 2025. 04 September 2024.

Table 3: SAF Blending Mandates by Country (%)

Country	SAF Mandate (%)	Starting Year	Policy Development	Status
Norway	0.5	2020	Aiming to increase 30% by 2030.	Implementing
Sweden	1	2021	Aiming to increase to 30% by 2030.	Implementing
France	1	2022	Aiming to increase 2% by 2025 and 5% by 2030.	Implementing
EU	2	2025	Under ReFuelEU released in October 2023, EU jet fuel suppliers must supply a 2% SAF blend from 2025.	Confirmed
UK	2	2025	UK SAF Mandate rolled out in April 2024, mandating 2% of jet fuel consumption must be filled by SAF from 2025.	Confirmed
Indonesia	5	2025	In 2024, Indonesian government introduced the plan to adopt 5% SAF Mandate from 2025.	In progress
Malaysia	1	2025	Under the National Energy Transition Roadmap published in 2023, 1% of SAF Mandate will be starting from 2025.	In progress
Turkey	1	2025	In 2022, Turkish government introduced the SAF Mandate draft of obliging 1% SAF blending from 2025.	In progress
Singapore	1	2026	Singapore government has proposed a national SAF Mandate of 1% by 2026.	In progress
Germany	0.5	2026	1% from 2028, 2% from 2030.	In progress
India	1	2027	1% from from 2027, 2% from 2028	In progress
***US**	20	2030	California passed a bill requiring the California Air Resources Board (CARB) to set a SAF target of 20% by 2030.	Under consideration
Japan	10	2030	In 2023, Japanese government published a proposal to have a national SAF Mandate of 10% by 2030.	In progress
Canada	3	2030	British Columbia has passed SAF legislation of 3% SAF blend by 2030.	In progress

Note: The US does not have a nationwide SAF mandate yet, but the California Low Carbon Fuel Standard (CA-LCFS) recognizes SAF as an eligible fuel to generate carbon credits[42] and targets 20% SAF blending by 2030.
Source: SkyNRG.

[42] IATA. Fact Sheet: EU and US policy approaches to advance SAF production.

The U.S., a major jet fuel importer for South Korea[43] and the world's second-largest jet fuel exporter, aims to become the leading SAF producer. This ambitious goal is fueled by government incentives and subsidies, with expected production capacity reaching around 10 Mt per year by 2030.[44]

The U.S. government's recent IRA further strengthens its lead in SAF production. The regulation allocates US$291 million in grants for SAF and low-emission aviation technologies[45] alongside tax credits of US$1.25 to US$1.75 per gallon (US$0.33 to US$0.46 per liter) of SAF sold between December 2023 and 2024.[46] With these significant incentives and a long-term target of 100% SAF use by 2050, the U.S. is well-positioned to play a significant role in the future of sustainable fuel.

The EU is also poised to become an important player in SAF production. Through the ReFuelEU initiative and widely used co-processing technologies, the EU is expected to reach 3.8 Mt per year of SAF production by 2030.[47] Co-processing allows existing refineries to utilize diverse feedstocks like bio-oils and waste oils, making it a cost-effective approach for ramping up SAF production capacity.

The third-largest jet fuel exporter, the Netherlands, is projected to reach a SAF production capacity of 880,000 tonnes annually by 2028. This ambitious target highlights the Netherlands' commitment to decarbonizing the aviation sector.

Singapore, the world's fourth-largest jet fuel exporter, has taken a proactive approach to SAF with foreign direct investment (FDI). Finnish company Neste's new 1 million tonne-per-year SAF plant in Singapore has been operational since 2023. This move demonstrates Singapore's commitment to capturing a leading role in the burgeoning SAF market. Table 4 below compares SAF plans of leading aviation export markets.

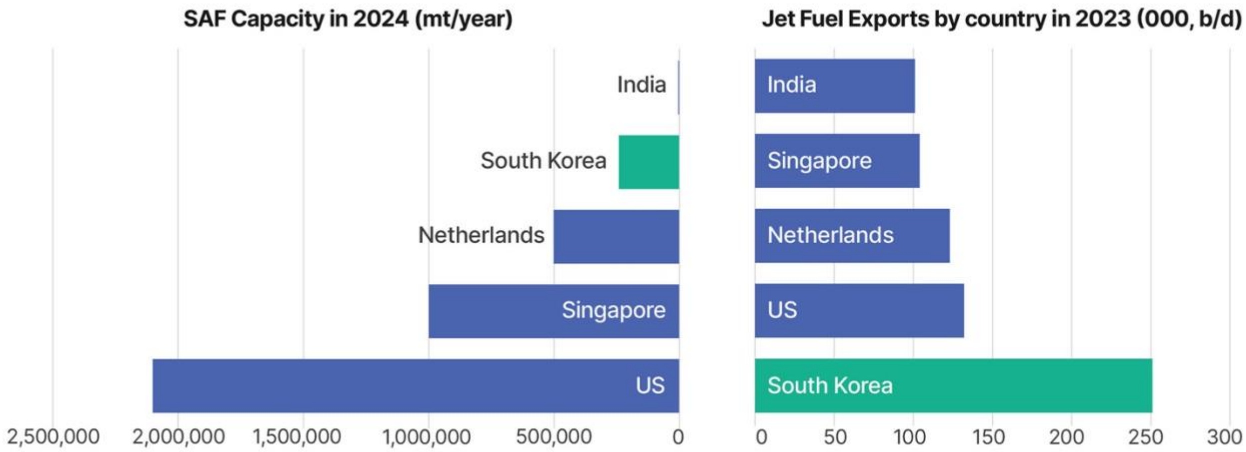
[43] Around half of jet fuel imports from the US are from South Korea. Maeil Economic Daily. Half of the jet fuel imported by the US comes from South Korea, IRA could pose a significant threat to South Korean exporters. 24 October 2024.
[44] U.S. Department of Energy. Sustainable Aviation Fuel Grand Challenge.
[45] Carbon Pulse. US carves out nearly $300 mln from IRA for SAF. 21 August 2024.
[46] Maeil Economic Daily. Half of the jet fuel imported by the US comes from South Korea, IRA could pose a significant threat to South Korean exporters. 24 October 2024.
[47] Co-processing is one of the widely adopted technologies, followed by hydroprocessed esters and fatty acids (HEFA), which uses vegetable oils, animal fats, and waste cooking oil as feedstocks. HEFA can use existing jet fuel production facilities but is not a straightforward drop-in technology like co-processing. Hence, higher costs are involved compared to co-processing.

Table 4: SAF Competitor Analysis Jet Fuel vs SAF

Country	Ranking in Jet Fuel Exports	Jet Fuel Exports in 2023 (Thousand b/d)	SAF Mandate	SAF Capacity as of 2023-2024 (mt/year)	SAF Production Initiation	SAF Subsidies/ Tax Incentives
South Korea	1	251	1% from 2027	240,000	from Q4 2024	Tax breaks, other incentives, in progress
United States	2	132	None	2.1 million	2018	Producers of qualifying SAF are eligible for a tax credit of $1.25 to $1.75 per gallon produced under IRA.
The Netherlands	3	123	2% from 2025	400,000	2024	Companies investing in SAF production facilities are eligible for a tax credit of 27% to 45% on the investment.[1] Airports subsidies airlines €500/ ton of SAF.[2]
Singapore	4	104	1% from 2026	1 million	2023	Introduced airline levy system from 2026 to create fund to promote production and use of SAF.
India	5	101	1% from 2027	3,200	2024	None

Note: The U.S. partially adopted the SAF mandate in California aiming to use 20% SAF by 2030. SAF Capacity as of 2023 is an estimate.
Source: IEEFA; Industry.

Figure 6: SAF Capacity vs Jet Fuel Exports by Country



Note: SAF capacity in 2024 for South Korea is based on 2022 data.
Source: IEEFA; Industry.

South Korean Refiners' Plans

While global competitors ramp up SAF production, South Korean refiners (SK Energy, Hyundai Oilbank, and S-Oil) are preparing for commercial operations by the fourth quarter of 2024, with a combined capacity of around 420,000 metric tonnes (mt) per year (Table 5).

Table 5: SAF Production Plans Announced by South Korean Refiners

Company	SAF-related Business Development	SAF Production Capacity by 2030 (mt/year)	SAF Commercial Operation	Technology
SK Energy	✓ Acquire 100% of shares of SAF feedstock company, Daekyung O&T. ✓ SAF technology development MOU with Japanese ENEOS. ✓ SAF production facilities in Ulsan start-up (First SAF exclusive production line in South Korea).	620,000 mt/year	2024, 120,000 mt/year	Co-processing/ HEFA
GS Caltex	✓ Signed MOU with POSCO International to develop a next-generation biofuel business, including SAF production in Indonesia. ✓ Procured SAF from Neste and supply to Korean Air.	NA	2026, 250,000 mt/year	NA
Hyundai Oilbank	✓ Exports SAF to Japanese airliner, ANA. Acquired ISCC CORSIA.	250,000 mt/year	2024, 150,000 mt/year	Co-processing/ HEFA
S-Oil	✓ Acquired ISCC CORSIA for the first time in South Korea.	650,000 mt/year	2024, 150,000 mt/year	Co-processing
Hanwha TotalEnergies	✓ Signed an MOU last year with the Korea Petroleum Quality & Distribution Authority, Incheon International Airport Corporation, Korea Airports Corporation, Korea Petroleum Association, and Korea Aviation Association for the "SAF Demonstration Research Project".	270,000 mt/year	2027, 270,000 mt/year	HEFA

Source: IEEFA; Company data; Korean media news articles; Industry.

Leveraging South Korea's Advanced Recycling System

Many governments encourage shifting from first to second-generation SAF feedstocks, including waste-based components, for environmental and sustainability considerations.

Second-generation feedstocks, which include agricultural residues, MSW, and other non-food-based materials, are projected to grow significantly, especially after 2030, as technology advances and infrastructure expands. Scaling second-generation SAF will be crucial for the industry to meet future targets sustainably.

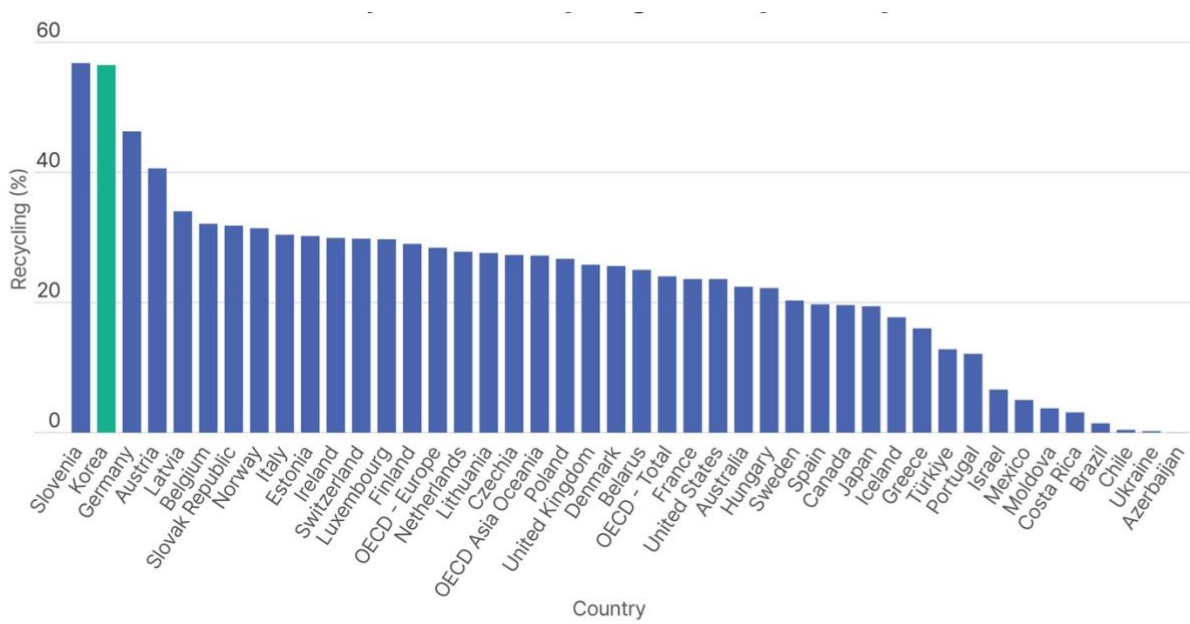
The advanced recycling system in South Korea presents significant opportunities for the country to emerge as a leader in SAF production and its supply chain.

South Korea has one of the world's best waste recycling systems (86% recycled waste)[48] and is ranked second in the Organization for Economic Cooperation and Development (OECD) for municipal waste recycling (56.5%). The country could leverage this strength to become a leading SAF producer (Figure 7).[49]

However, delayed domestic supply uptake for SAF could be an obstacle. Increased reliance on external SAF feedstocks, such as imported used cooking oil or vegetable oils, threatens energy security and underutilizes South Korea's advanced recycling program.

South Korea could leverage its recycling program to collect domestically aggregated used cooking oil for HEFA and co-processing production, and MSW for FT and ATJ pathways. Domestic feedstock procurement could reduce reliance on imported raw materials, potentially moderating SAF production costs and hedging feedstock availability.

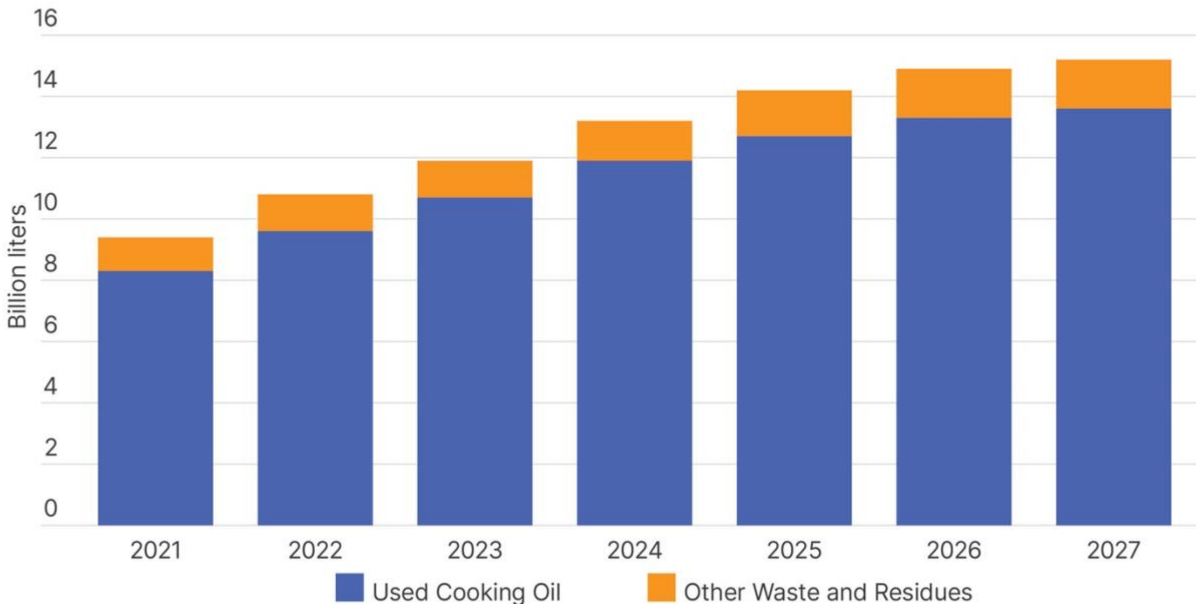
Figure 7: Municipal Waste Recycling Rates by Country (%)



Source: OECD.

[48] Ministry of Environment. Website.
[49] Municipal waste is one of the major feedstocks for making SAF via Fischer-Tropsch (FT) and co-processing technologies.

Figure 8: Biofuel Production by Waste and Residues



Source: IEA.

The timely development of a domestic SAF supply chain is crucial for South Korea to avail market opportunities. For instance, the collection of used cooking oil, a vital feedstock for HEFA and co-processing-based SAF production, could pave the way for new business ventures in the country.

Establishing a robust used cooking oil collection network would enhance energy security and improve the competitiveness of local SAF producers and the airline industry.

Furthermore, South Korea's strong recycling infrastructure can support FT and ATJ[50] pathways utilizing abundant MSW as feedstock. These technologies offer a distinct advantage over HEFA by reducing dependence on limited resources, like used cooking oil, ensuring a more sustainable and resilient supply chain.[51]

The carbon footprint of the feedstock used to produce SAF significantly affects the overall reduction of emissions. Waste-based feedstocks (like used cooking oil and MSW) tend to have lower carbon footprints than first-generation food-based feedstocks.

[50] There is controversy surrounding this technology, as using captured CO_2 via CCUS may prolong reliance on fossil fuels and diminish the carbon reduction benefits of SAF.
[51] Samsung Securities. ESG, decarbonization pathways in aviation. 19 July 2023. Page 19.

SAF production relies on sophisticated infrastructure for feedstock collection, refining, and distribution, which remains underdeveloped globally. Leveraging South Korea's advanced waste management system can improve SAF feedstock availability and reduce costs.

Converting municipal waste to fuel helps reduce landfill use and addresses waste management issues, making it a valuable resource in the circular economy. However, processing municipal waste into SAF can be technically complex and expensive due to its mixed nature. Extensive sorting and advanced technology are required to convert it into a viable fuel, necessitating further technological advancement based on rigorous research and development.

South Korea's recent commitment to the COP29 Reducing Methane from Organic Waste Declaration[52] in November 2024 highlights the need for a more transparent and systematic approach to waste management. Prioritizing second-generation feedstock collection and utilization can also mitigate the ethical and environmental risks associated with first-generation SAF feedstock.

Conclusion

The International Renewable Energy Agency's (IRENA) 1.5°C Scenario projects that bioenergy, including SAF, will comprise "over 18% of the total final energy consumption (TPEC) by 2050."[53] Given its energy density, SAF is considered among the most viable options for hard-to-abate sectors like aviation.

However, widespread SAF adoption must align with effective governance to mitigate risks associated with land and resource utilization, food security, natural ecosystems, and carbon stocks while fostering equity, justice, and economic competitiveness.

Though challenges remain in the transition to SAF, South Korea's strategic initiatives, existing strengths in waste recycling, and leading position in the conventional jet fuel market will be advantageous in the emerging industry. The timely development of a domestic SAF industry is crucial for leveraging these opportunities and achieving a greener aviation future.

[52] Middle East Economy. COP29: 35 countries endorse 'reducing methane from organic waste declaration'. 21 November 2024.
[53] IRENA. The Role of Sustainable Bioenergy in Supporting Climate and Development Goals. 20 June 2024.

About IEEFA

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