Fuelling a cleaner sky

India's opportunity in sustainable aviation fuel

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Executive summary

The aviation industry is on a strong growth trajectory, fuelled by rising domestic and international travel. However, this growth also contributes to rising carbon emissions, prompting an urgent need to decarbonise. Sustainable aviation fuel (SAF), derived from renewable feedstocks such as agricultural residue and municipal waste, offers a viable pathway, delivering significant emissions reductions while remaining compatible with existing infrastructure at blend ratios of up to 50 per cent.

With countries worldwide incorporating sustainability in their aviation strategies, India's booming aviation sector is well positioned to integrate SAF into its expansion plans. With abundant biomass resources and evolving waste-to-energy capabilities, India has the potential to scale SAF production and embed it into its aviation growth plans. By aligning policy, infrastructure and innovation, India can not only meet its net-zero ambitions but also emerge as a global hub for sustainable aviation.

India's surplus biomass advantage

India generates ~**230 million tonnes** of surplus agricultural waste, offering strong potential for SAF production

India's SAF production could reach **19-24 million tonnes,** more than twice the demand by 2030, creating strong export opportunities

To drive this transition, India has set a SAF blending target of **1 per cent for international flights by 2027**

Government and industry-led initiatives

Government policies such as Bio-ATF* programme and blending mandates are creating a favourable environment for SAF development

SAF companies are steering efforts towards the alcohol-to-jet (ATJ) pathway using renewable ethanol, with pilot projects underway

Partnerships between fuel producers, technology companies and airlines are advancing the development and deployment of SAF

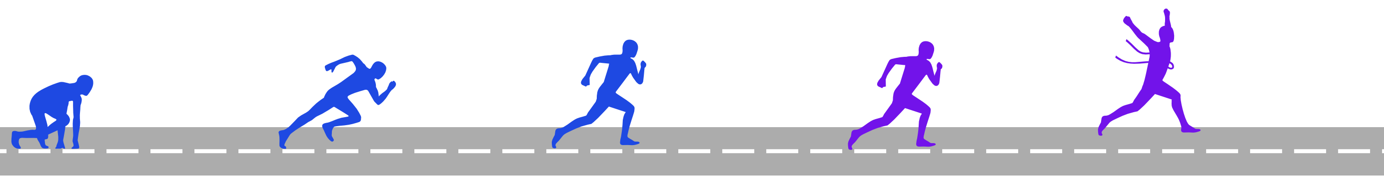
Airlines in India are driving SAF adoption by operating pilot flights and conducting feasibility studies

*Aviation Turbine Fuel

Barriers to SAF production

- **High production costs** make it less economically viable compared to fossil fuels
- **Supply chain bottlenecks** disrupt the steady flow of raw materials
- **Gradual evolution of technical expertise** slows down innovation and efficient scaling
- **Infrastructure limitations** restrict widespread adoption
- **Competing utilisation demand for biomass** reduces its availability for SAF.

Paving the way for a greener aviation future



Promoting sustainable feedstock cultivation

Developing refining and blending infrastructure

Promoting SAF deployment in airports

Strengthening supply chain efficiency

Making SAF cost-competitive

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Rising aviation emissions and the need for SAF

The growing aviation sector and its emissions footprint

As global connectivity deepens, the aviation industry is experiencing robust growth driven by surging passenger demand and increased capital investments. Despite severe disruptions caused by COVID-19, the sector has reaffirmed its role as a vital component of global connectivity and commerce, with growth evident across both mature and emerging markets. Among these, the Asia-Pacific region stands out as a key driver of growth, where air passenger traffic is expected to surpass the global average. This is prompting a strategic shift across the industry, with a focus on fleet expansion and route diversification to meet evolving demands.

USD979 billion

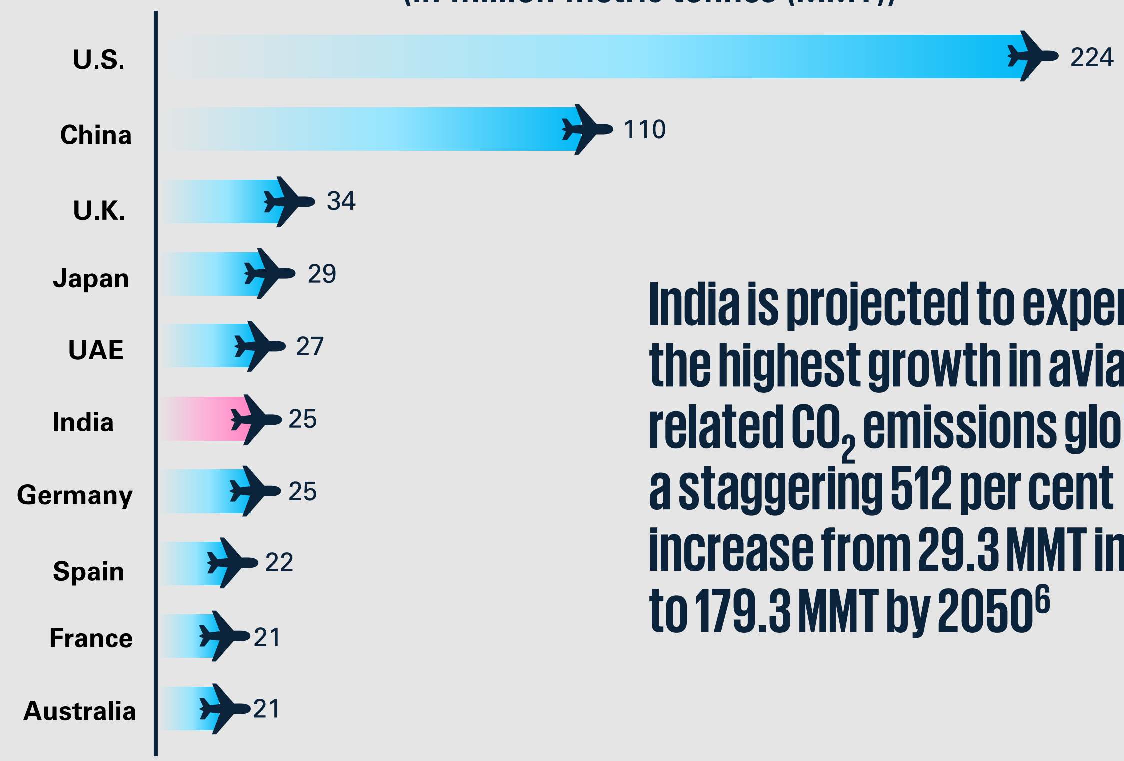
Forecasted revenue of global aviation industry in 2025 (1.3 per cent y-o-y growth)[2]

34.7 per cent

Share of Asia-Pacific in global passenger traffic in 2023[3]

While the aviation sector's growth is enhancing global connectivity and mobility, it is simultaneously intensifying environmental pressures. The rise in aircraft operations directly correlates with increased fuel consumption, leading to a significant surge in carbon emissions. In 2024, emissions from air transport reached 942 million tonnes of carbon dioxide (CO_2), reflecting a sharp increase of nearly seven per cent over the previous year[4].

Top countries with the highest flight-related CO_2 emissions in 2024 (in million metric tonnes (MMT))[5]



India is projected to experience the highest growth in aviation-related CO_2 emissions globally, a staggering 512 per cent increase from 29.3 MMT in 2019 to 179.3 MMT by 2050[6]

India's booming aviation brings emissions challenges

India, one of the fastest-growing emerging economies, is experiencing shifts in consumer behaviour and mobility patterns, driven by urbanisation, rising disposable incomes and widespread digital connectivity. A key indicator of this progress is the surge in air travel, which has propelled India to become the world's third-largest aviation market[7]. This growth is contributing to improved national connectivity and fostering regional development.

As aviation continues its upward trajectory, fuel consumption is projected to rise sharply, positioning the sector as a growing contributor to carbon emissions. This trajectory presents a challenge to India's climate commitments, particularly its aim of achieving net zero emissions by 2070[8]. Addressing this may require strategic measures, including the integration of biofuels, operational enhancements and targeted investment in low-emission technologies.

Emissions set to grow as India's aviation sector expands

Infrastructure development

India's operational airports have grown from 74 in 2014 to 157 in 2024, with a target of 350-400 by 2047[9]

Expanding passenger market

India's domestic air passenger traffic rose by 7.7 per cent in FY25, reaching a projected 165.5 million, with estimates suggesting an increase to 300 million by 2030[10,11]

Rising aircraft fleet

Airlines in India have a five-year order pipeline of 739 aircrafts and are expected to require over 2,200 aircraft by 2042[7,12]

Surge in ATF consumption

In FY25, ATF consumption recorded an 8.9 per cent y-o-y increase, indicating growing operational activity in the aviation sector[10]

Improved regional connectivity

Regional connectivity has surged under the RCS-UDAN* scheme, launching 619 routes and linking 88 airports, with 120 more destinations planned[13]

*RCS-UDAN: Regional Connectivity Scheme – Ude Desh Ka Aam Nagrik

With the expansion of low-cost carriers and growing airport infrastructure, it is vital to ensure that aviation development remains sustainable. Without proactive measures, the sector risks undermining national climate goals and exacerbating existing air quality issues. This calls for a multi-pronged decarbonisation approach that integrates regulatory frameworks, industry innovation and cleaner technologies.

Decarbonising aviation through sustainable interventions

The surge in emissions from the growing aviation sector underscores the pressing need for sustainable and scalable solutions. As environmental concerns intensify, ranging from deteriorating air quality to climate change and global warming, decarbonising aviation has become a strategic imperative. Achieving meaningful reductions in greenhouse gas (GHG) emissions demands a comprehensive approach that integrates robust policy frameworks, cross-sector collaboration and technological innovations.

International organisations are playing a pivotal role in guiding the sector towards sustainability. The International Air Transport Association (IATA), in partnership with its member airlines, has pledged to achieve net-zero carbon emissions by 2050, a milestone commitment for global aviation. Similarly, the International Civil Aviation Organisation (ICAO) introduced the Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA) in 2016, a global initiative designed to accelerate the sector's transition to a low-carbon future[14].

CORSIA

CORSIA is a market-based mechanism designed to achieve carbon-neutral growth in international aviation. Airline operators emitting over 10,000 tonnes of CO_2 annually are required to track, report and verify international flight emissions each year, with 2019 as the baseline year. Participation is voluntary during the initial phase from 2021 to 2026, before becoming mandatory in the subsequent phases[14].

Pilot phase (2021-2023)

First phase (2024-2026)

Second phase (2027-2035)

Voluntary participation

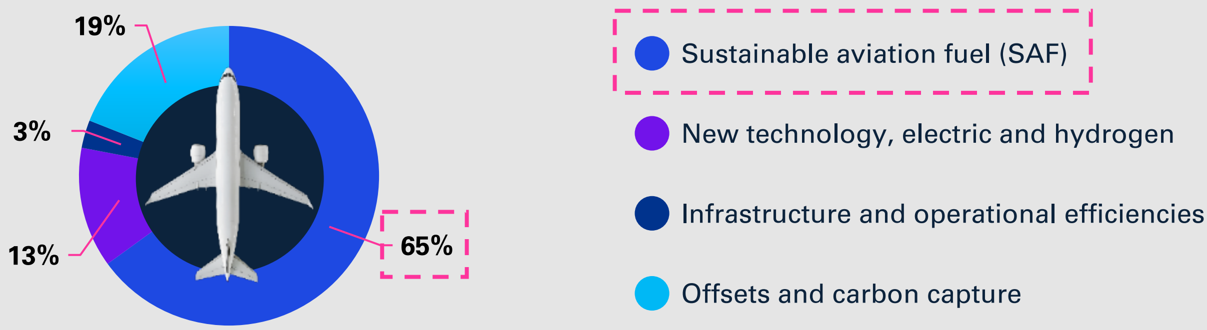
Mandatory participation will be determined using 2018 RTK* data and exemptions based on aviation and socio-economic criteria

*RTK: Revenue Tonne Kilometre

As of 1 January 2025, 129 countries are participating in CORSIA. India has opted out of its voluntary phase, with offsetting requirements for its airlines set to begin from 2027[14,15]

While CORSIA provides a foundation for monitoring and offsetting emissions, achieving true decarbonisation requires a broader set of transformative actions. The path to net-zero is multifaceted and relies on a combination of strategies. Among these, SAF is projected to play a pivotal role by potentially contributing around 65 per cent of the total emissions reductions for aviation to achieve net-zero carbon emissions by 2050[16].

Emission reduction pathways for cleaner aviation[16]



Significance of SAF in decarbonisation

Among the various approaches to decarbonising aviation, the use of SAF is recognised as one of the most promising technological solutions. It is a liquid fuel utilised in commercial aviation, offering up to 80 per cent reduction in CO_2 emissions[17]. Although its hydrocarbon structure closely resembles that of conventional fossil fuels, resulting in similar tailpipe emissions, the key difference lies in its origin. SAF is derived from sustainable sources, including waste fats and oils, non-food crops and municipal solid waste. Additionally, it can be produced synthetically through a process that captures carbon directly from the atmosphere.

The sustainability of SAF is rooted in its feedstock, which avoids competition with food production or water resources and does not contribute to deforestation. Unlike fossil fuels that release ancient carbon, SAF sources its carbon from materials that have absorbed CO_2 from the atmosphere during their growth. When burned, it returns this carbon to the atmosphere, effectively creating a closed-loop system that reduces net GHG emissions and supports long-term climate goals.

Scenario-based projections of aviation-related CO_2 emissions between 2022 to 2050 (billion metric tonnes)[18]

	2022	2025	2030	2040	2050
No action taken	0.9	1.1	1.1	1.4	1.8
Enhancements in aircraft design, flight procedures and ground operations	0.9	1	1	1.1	1.4
Deployment of SAF (% reduction in CO_2 emissions compared to no action taken)	0.9	1 (9%)	1 (9%)	0.6 (57%)	0.4 (78%)

The projected scenarios of emissions highlight that, while operational and technological enhancements such as improved aircraft design and optimised flight procedures can contribute to reducing emissions, their impact remains relatively modest. In contrast, the deployment of SAF represents a transformative solution, capable of delivering substantially greater emission cuts compared to other measures, thereby reinforcing its central role in aviation's decarbonisation efforts. As demand for air travel continues to rise, SAF offers a pragmatic solution to mitigate climate impact, positioning it as a strategic pillar in the industry's journey towards carbon-neutral growth.

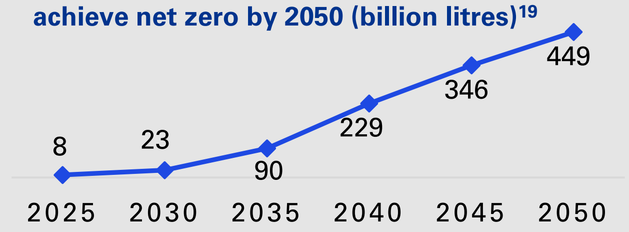
Mapping SAF deployment status globally

Given SAF's key role in reducing aviation emissions, the focus is increasingly shifting towards its global deployment. By the year 2050, aviation's reliance on SAF is expected to increase as part of a broader transition to cleaner energy sources, including green hydrogen and low-carbon electricity. This transition is expected to result in the establishment of approximately 5,000 to 7,000 new SAF production facilities worldwide, potentially generating around 14 million jobs[17].

Expanding the production of SAF demands the development of new infrastructure, the formation of commercial alliances and enhancements in the supply chain.

The SAF industry utilises diverse feedstocks from across the globe, strengthening energy security, autonomy and resilience. Production is likely to be more regionally distributed, situated closer to feedstock sources and airports.

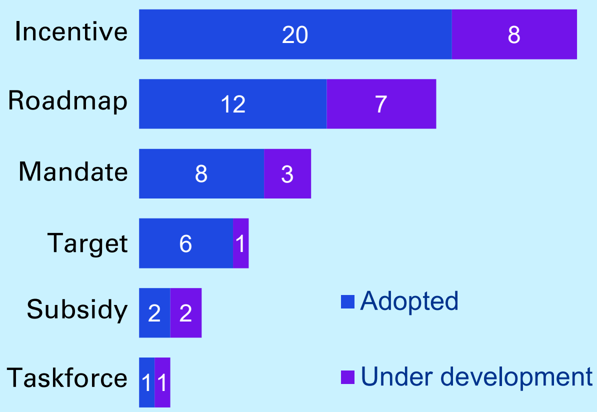
Estimated global SAF requirement to achieve net zero by 2050 (billion litres)[19]



To accelerate SAF adoption, governments globally are developing policies such as introducing mandates, setting targets and outlining roadmaps. However, given SAF's nascent stage in market development, mandates alone may not suffice. These efforts should be complemented by a broader strategy that includes supportive incentive programs aimed at fostering innovation, scaling production and reducing costs. As global momentum builds, international collaboration is essential to align efforts, share best practices and ensure that SAF development is both ambitious and achievable.

Global SAF deployment tracker*[20]

Category-wise breakdown of SAF policy counts worldwide



- The U.S. has around 163 SAF production facilities with an announced capacity of nearly 54,280 million litres per year, followed by Canada (36) and the United Kingdom (U.K.) (26)
- Of the 175 airports currently supplying SAF, 71 have received it once, through what are known as 'batch deliveries'. The remaining 104 airports receive SAF on a regular basis, ensuring consistent availability for departing flights
- Approximately certified 137 batches of SAF have been approved under the CORSIA framework, supported by 49 recognised feedstock types.

546 Announced SAF facilities

USD67.6 billion Announced investments for SAF production

54 billion Litres of SAF under the offtake agreements

175 SAF distributing airports

83 Policies adopted or under development

*The data is as accessed on 28 October 2025

02

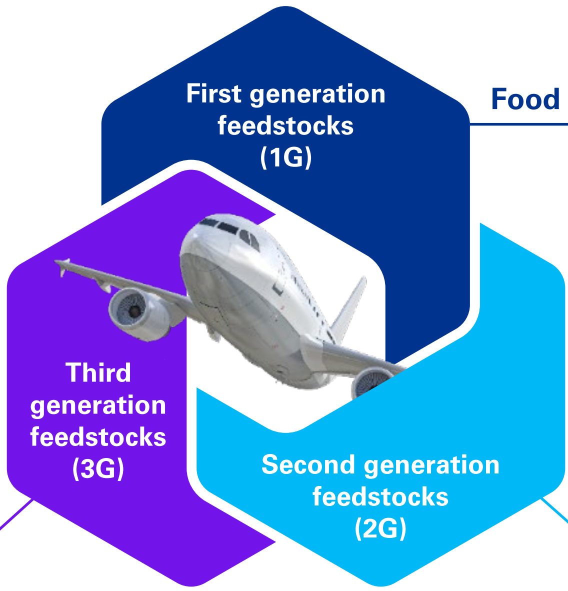
SAF fundamentals: Feedstocks and production technologies

While SAF adheres to the same technical and safety specifications as conventional aviation fuel (CAF) and consequently releases an equivalent amount of CO_2 during combustion, its environmental benefits stem from its production process. SAF is derived from non-fossil sources, including a diverse range of biogenic and non-biogenic feedstocks, which contribute to a lower lifecycle carbon footprint.

Environmentally friendly feedstocks are those derived from waste materials as they do not compete with food crops or require additional land use. This approach helps reduce carbon emissions and lowers the overall ecological footprint of the fuel.

Feedstocks powering the cleaner aviation fuel

Three broad generations of feedstocks have been classified by the industry, primarily based on their order of adoption. Other factors such as capacity to meet wider sustainability standards, emission reduction potential, ability to support healthier ecosystems and global availability may vary across generations[1].



Food grade fats and oils

1G feedstocks have scaled commercially and are generally more cost-effective to produce compared to other types of feedstocks.

Palm oil and derivatives, canola/rapeseed oil, corn, soybean oil, sunflower oil

Bio/agricultural wastes and residues

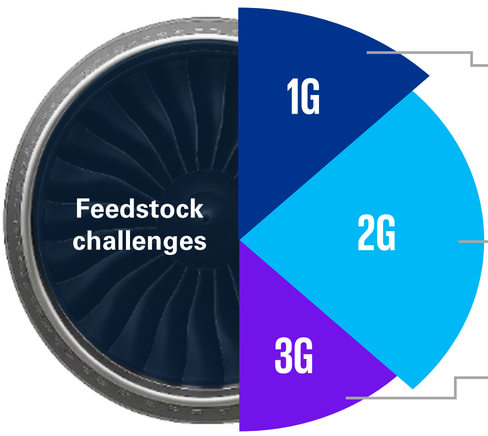
3G feedstocks are naturally abundant, benefit from relatively lower associated costs and offer significant potential for delivering positive environmental benefits.

Algae oils, food waste, wet waste, municipal solid waste, agricultural residues and forestry

Food grade fats and oils

2G feedstocks tend to be among the more expensive of the three categories, as they are derived from waste materials linked to industrial activities, implying a constrained supply.

Used cooking oil, inedible animal fats and tallow, trap grease, fatty acid distillates



Competition with global food production, high demand for arable land and risk of deforestation

High cost, limited availability due to dependence on industrial waste streams

Need for advanced processing technologies, leading to higher complexity and cost

Harnessing diverse feedstocks for a resilient SAF supply chain

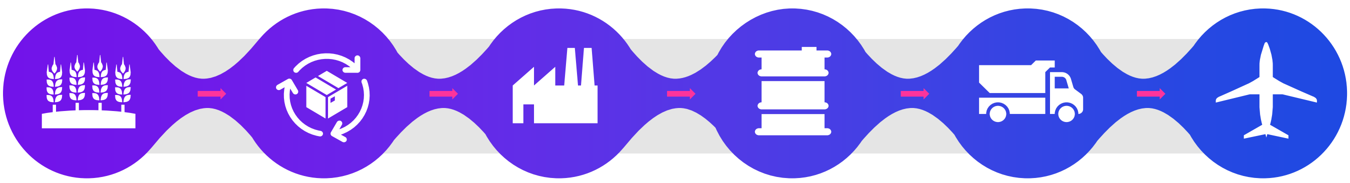
SAF production benefits from the ability to utilise a wide range of feedstocks, unlike fossil fuels which are restricted to specific extraction sites. This adaptability enables a geographically diverse sourcing model, enhancing energy security for the aviation sector as well as regional economies. Feedstocks used in SAF production can be cultivated across diverse climatic conditions and geographical regions, aligning fuel production with regional demand. This diversity not only supports scalable fuel generation but also strengthens the resilience and adaptability of the SAF supply chain, enabling more regionally responsive fuel distribution networks.

Factors impacting feedstock availability

- Location
- Climate and weather
- Seasonality
- Market demand

Other factors include **labour, collection methods, trade rules, pests and economic shifts**

The SAF supply chain encompasses a series of steps, beginning with the sourcing and aggregation of feedstocks, followed by their conversion into fuel at dedicated processing facilities. The resulting fuel is then transported and integrated into airport fuelling infrastructure to support aviation operations. Currently in their nascent stage, these supply chains remain limited in scale and region-specific based on feedstock availability.



Ensuring SAF safety and performance through compliance

For SAF to be deployed in commercial aviation, it must comply with the standards outlined in American Society of Testing and Materials (ASTM) D7566, the internationally recognised specification governing aviation turbine fuels containing synthesised hydrocarbons. ASTM International is a global organisation that sets consensus-based technical standards, ensuring SAF meets the stringent safety and performance requirements of conventional jet fuel. The current maximum blending limit for SAF with conventional Jet A fuel is up to 50 per cent, depending on the production technology[1].

In India, the Bureau of Indian Standards (BIS) has formulated IS 17081:2019 Aviation Turbine Fuel (Kerosene, Jet A-1) that includes synthesised hydrocarbons. Developed in collaboration with the Indian Air Force (IAF), research bodies and industry stakeholders, the standard aligns with international norms to support the use of bio-jet fuel in both military and civil aviation. It facilitates domestic production by outlining the parameters for blending conventional and synthetic components in defined ratios[2].

Production technologies for SAF

There are 11 ASTM approved methods for making sustainable jet fuel, with 11 other technologies currently undergoing assessment for future approval. These pathways yield SAF alongside other co-products during the refining process and the volume of SAF produced can differ significantly depending on the method used. Consequently, some pathways may have limited capacity to produce SAF compared to other fuel production approaches[3]. Some of the key select technologies include:

Production technology	Viable feedstock option	Pros and cons
Hydroprocessed Esters and Fatty Acids (HEFA)	Animal fat Vegetable oil Used cooking oils	**Pros**: Proven and widely used; currently the most affordable SAF option **Cons**: Limited feedstock and risk of supply chain disruptions
Alcohol-to-jet synthetic paraffinic kerosene (ATJ-SPK)	Ethanol Isobutene Isobutanol	**Pros**: Established technology with low capital requirements **Cons**: Low carbon reduction potential (vs. other SAF pathways)
Fischer-Tropsch synthesised paraffinic kerosene/ Synthesised kerosene with aromatics (FT-SPK/SKA)	Coal Biomass Natural gas	**Pros**: Low sulfur and aromatics **Cons**: Limited feedstock and prone to supply chain issues
Catalytic hydrothermolysis jet fuel (CHJ)	Animal fat Vegetable oil Used cooking oils	**Pros**: Ideal for processing wet biomass **Cons**: Technology is still in early stages

The above production technologies support a maximum blend ratio of 50 per cent[3]

Power-to-liquid (PtL) SAF or e-fuel

Among the various sustainable fuel options, PtL or e-fuel stands out as an **innovative form of synthetic SAF**. It is synthesised through a process that integrates green hydrogen and captured CO_2. Green hydrogen is produced via electrolysis using renewable energy such as wind or solar, while CO_2 is sourced directly either from the atmosphere or from industrial emissions.

The fuel is manufactured via the **Fischer-Tropsch* process** and is poised to become a critical enabler in the aviation industry's decarbonisation strategy. However, its commercial scalability remains constrained by **technological limitations and infrastructure readiness.** Despite these constraints, substantial progress of e-fuels is expected from the **mid-2030s,** contingent on the accelerated deployment of renewable energy and carbon capture systems[1].

*It converts solid biomass, including waste residues, into synthetic gas, which is then refined into hydrocarbons used in road and aviation fuels[4].

Pioneering SAF technologies: HEFA and ATJ

SAF can be produced through multiple technological pathways, defined by the type of feedstock, the conversion process applied and the resulting fuel characteristics. These approaches are broadly categorised into commercially established methods, such as HEFA and ATJ and emerging or developmental pathways. HEFA and ATJ, which have gained traction due to their technical maturity and regulatory approval, are projected to contribute approximately 89 per cent of near-term SAF output by 2030 (HEFA at 66 per cent, ATJ at 23 per cent)[5].

1 HEFA

HEFA is currently a commercially established and widely adopted route for SAF production, accounting for approximately 80 per cent of global SAF output. Its global standalone production capacity is estimated at 4 to 5 million tonnes, with projections suggesting this could double by 2030[6]. The U.S. and Europe lead global efforts in SAF production through the HEFA pathway, supported by investment incentives and technological expertise.

HEFA can be derived from a wide array of oils and fats that contain triglycerides or fatty acids.

- Used cooking oil (UCO)
- Animal fats, palm oil mill effluent (POME)
- Palm fatty acid distillate (PFAD)
- Other oils (e.g. tall oil, technical corn oil)

HEFA-based SAF needs 2-19 times more hydrogen per gallon of fuel produced than fossil jet production, making sourcing a key challenge[7]

Standalone HEFA units are currently optimised for producing renewable diesel, largely due to favourable policy support and their strong position among distillate products. However, with basic modifications, these existing units could easily increase SAF output to 15-20 per cent of their total production, potentially adding around one million tonne of SAF volume[6].

2 ATJ technology

ATJ is an approved SAF production technique that involves converting sugar and starch-rich biomass into ethanol or other renewable alcohols through fermentation into jet-grade hydrocarbons. It is a mature and scalable SAF technology that can reduce GHG emissions by over 80 per cent[8].

ATJ feedstocks are refined into ethanol and isobutanol, which serve as key feedstocks in the ATJ fuel production pathway.

- Wood
- Sugarcane
- Corn
- Sugar
- Molasses
- Residual starch

Sugarcane must be converted to ethanol within hours of harvest, requiring fast, coordinated logistics despite its availability

Ethanol is produced in much larger volumes than fats and oils, giving the ATJ process an edge in feedstock availability. Although ATJ requires a relatively greater amount of ethanol than HEFA needs fats and oils for fuel production, ethanol's broad availability and lower cost make ATJ a more viable and scalable option for developing SAF.

03

Mapping the global SAF landscape

Advancing SAF worldwide: Production practices and mandates

In 2024, global SAF production reached one million tonnes, which was consumed by airlines at a steep cost of USD2,350 per tonne, over three times the price of conventional jet fuel, adding USD1.6 billion to the industry's fuel expenses. While production is expected to double in 2025, SAF is still projected to meet only 0.7 per cent of total aviation fuel demand, underscoring the need to scale up its availability and affordability[1].

Countries are advancing SAF deployment through targeted policy measures such as blending mandates, financial incentives and tax credits. Many have initiated production using defined feedstocks and approved technologies to build initial capacity.

How SAF is currently produced globally

U.S.

- Three operational facilities, two use HEFA pathway and one uses ATJ pathway, having annual production capacities of 10 million gallons or more[2]

Europe

- Operational facilities in France, Finland, Germany, Italy, the Netherlands, Spain and the U.K. use HEFA technology
- In Germany, 24 out of the 28 planned, projected and operational projects are focused on synthetic fuels such as PtL SAF[3]

Asia-pacific

- Operational plants in China, Singapore, South Korea and Thailand utilising the HEFA pathway
- A demonstration plant in Japan is adopting FT technology to produce SAF with woody biomass, while a pilot facility in Singapore is focused on PtL SAF.

Global SAF blending mandates to accelerate the transition to cleaner fuels

To encourage investment and consistent SAF adoption worldwide, several countries have introduced or are actively considering SAF blending mandates as part of their broader decarbonisation strategies. These mandates require airlines to mix a set percentage of SAF with conventional jet fuel, initially targeting international flights, with domestic routes likely to follow for cost efficiency. Below are the SAF blending mandates introduced by various countries and regions.

Canada*
1 per cent in 2028
3 per cent in 2030[4]

European Union
6 per cent by 2030
70 per cent by 2050[5]

Germany*
1 per cent by 2028
2 per cent by 2030[4]

Norway*
0.5 per cent since 2020
6 per cent by 2030[6]

U.K.
10 per cent by 2030
22 per cent by 2040[7]

*Mandate for Canada is available specifically for British Columbia, a province in the country; Mandate for Germany is a PtL blending target; Norway currently has its own mandate but aims to adopt the ReFuel EU regulation targets by the end of 2027 at the latest.

While several nations have introduced mandates for SAF production, the U.S. has set a national target to produce at least 3 billion gallons of SAF annually by 2030, with a long-term goal of reaching 35 billion gallons by 2050, enough to meet 100 per cent of domestic aviation fuel demand[8].

Global approaches to SAF deployment

United States

- **The SAF Grand Challenge**
  A joint initiative led by DOT, DOE and USDA* to boost SAF demand, cut costs and scale production through coordinated research and development[8]
  - **SAF grants**
    USD50 million allocated by the FAA for SAF projects involving production, transport, blending and storage[9]
- **Clean Fuel Production Credit**
  Offers a tax credit up to USD1.75 per gallon for SAF, USD0.35 per gallon if prevailing wage and apprenticeship requirements are not met[10].

*DOT: U.S. Department of Transportation; DOE: U.S. Department of Energy; USDA: U.S. Department of Agriculture; FAA: Federal Aviation Administration

Europe

European Union (EU)

- **ReFuelEU aviation regulation**
  Ensures that all fuel suppliers are required to provide fuel to aircraft operators at EU airports containing the mandated minimum required proportions of SAF, including specified shares of synthetic aviation fuels[14].

Germany

- **Aviation Initiative For Renewable Energy In Germany (aireg)**
  A collaborative platform for members to develop innovative strategies and concepts to advance SAF deployment and meet ambitious targets[15].

U.K.

- **Advanced fuel fund**
  Provides financial support for SAF, currently backing 13 innovative projects with a USD180 million* fund to boost investment and reach commercial scale[11]
- **The clearing house**
  A Department for Transport-funded programme, advancing SAF through development, testing, and production support across aviation and related industries[16].

Asia Pacific

Japan

- **Public-Private Council**
  Promotes SAF through coordinated efforts of government, airlines and fuel suppliers, aiming to build a domestic supply chain and meet Japan's 10 per cent SAF usage target by 2030[11]
- **Financial incentives**
  A proposed corporate tax credit measure, proportional to the amount volume of the production (planned USD0.20 per litre*). For capital investments, subsidies will be offered through green transition bonds, already started from 2024[11].

Australia and New Zealand

- **The Sustainable Aviation Fuel Alliance of Australia and New Zealand (SAFAANZ)**
  A working group initiated by Bioenergy Australia, a national industry association, to create a collaborative platform for progressing SAF production, policy development, education and marketing in Australia and New Zealand[12]

Singapore

- **Singapore Sustainable Air Hub Blueprint**
  Advances SAF deployment through national targets, centralised procurement, regional production support and a levy to incentivise purchases and achieve SAF goals[13].

*The currency has been converted as per the conversion rate of JPY1 = USD0.0065 as of 28 October 2025
*The currency has been converted as per the conversion rate of GBP1 = USD1.3330 as of 28 October 2025

04

India's SAF advantage: From potential to future powerhouse

India's edge in SAF production

India has significant potential to emerge as a global leader in SAF production, underpinned by its vast and varied biomass resources. As an agrarian economy, India produces over 500 MMT[1] of agricultural residues annually, including crop stubble, oilseed byproducts and sugarcane bagasse, which serve as high-potential feedstocks for biofuel conversion.

Complementing this is the significant volume of municipal solid waste and used cooking oil generated across India's urban centres, further diversifying the SAF input base. This abundance of raw material creates an opportunity to build a resilient, scalable SAF supply chain. With strategic public investment, targeted fiscal incentives and enabling policy frameworks, India can accelerate infrastructure development and foster innovation across the SAF value chain. By aligning market mechanisms with sustainability goals, India can capitalise on its resource abundance, thus playing a key role in global SAF production.

India holds a strategic edge in SAF production due to its abundant bio-based feedstocks, such as agricultural residues, producing nearly 230 million tonnes of surplus biomass[2]. Combined with its cost-effective renewable energy capacities and growing technological infrastructure, the country is well placed to become a global frontrunner in biofuels and e-fuels.

Potential feedstocks and their surplus biomass residue[2]

Rice
41.7 million tonnes

Wheat
33.4 million tonnes

Maize
15.2 million tonnes

Sugarcane
6.4 million tonnes

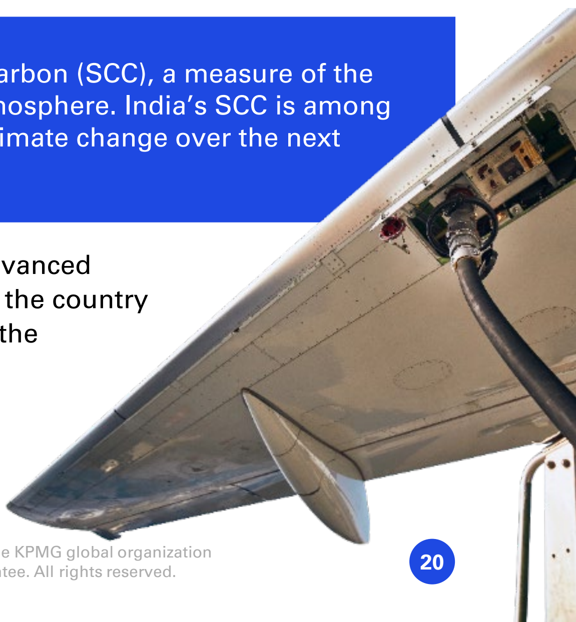
Other feedstock sources that can be harnessed

Used cooking oil (UCO)
India generates abundant volumes of used cooking oil and is a major vegetable oils consumer

Municipal solid waste
Around 161,157 tonnes of municipal solid waste generated per day in urban areas[3]

India's transition to SAF could significantly lower its social cost of carbon (SCC), a measure of the economic harm caused by each additional tonne of CO_2 into the atmosphere. India's SCC is among the highest globally and reflects the long-term financial impact of climate change over the next century or more[4].

Expanding SAF production in India presents an opportunity to build advanced technological capabilities, strengthen energy self-reliance and position the country as a significant contributor to the global SAF supply chain. To support the decarbonisation of aviation and enable sustainable sectoral growth, India can utilise a broad spectrum of certified technologies and environmentally responsible feedstocks to scale up green fuel production.



To realise this potential, India needs to strategically adopt and scale various SAF production pathways. Among these, ATJ stands out as a viable option, leveraging India's vast agricultural residue and biomass resources. HEFA, on the other hand, provides a cost-effective approach and aligns well with existing waste oil streams.

- **ATJ**: The pathway aligns with India's strengths in biomass availability and agricultural diversity, resources that are abundant across India's rural and semi-urban regions. With relatively low capital requirements, ATJ offers scalable opportunities for decentralised SAF production.
- **HEFA**: The pathway offers India a practical and cost-effective route to scale SAF production in the near term. With the lowest capital and operational costs among current technologies, HEFA is well-suited for early adoption.

India's ATJ advantage

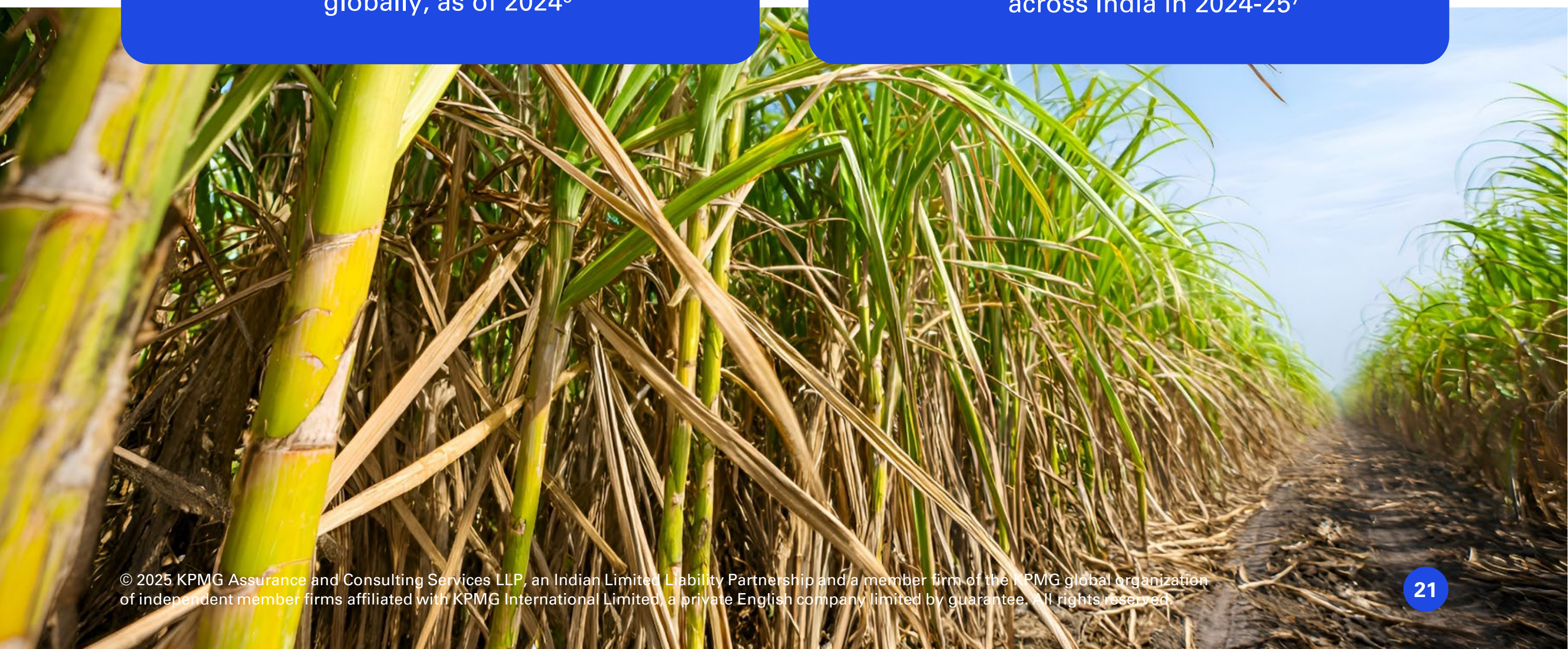
- India's abundant surplus biomass from sugar and starch-based feedstocks such as sugarcane and maize offers considerable potential for SAF production through the ATJ pathway
- Extensive sugarcane cultivation ensures a steady ethanol supply, supporting ATJ fuel production
- By September 2024, India's ethanol production capacity more than doubled over four years, reaching 16.2 billion litres under the Ethanol Blended Petrol (EBP) programme. This growth reflects a notable rise in ethanol blending, which increased from 1.53 per cent in 2014 to 15 per cent in 2024[5]
- Indian organisations are exploring ATJ technology through pilot initiatives and strategic collaborations, positioning it as a scalable SAF pathway within the country's growing biofuel landscape.

India's HEFA potential

- India has substantial feedstock potential for the HEFA pathway, notably from UCO and PFAD
- As one of the major edible oil consumers, India generates significant UCO from household and industrial sources
- Improved infrastructure could enable large-scale UCO utilisation, despite current challenges in collection and widespread improper disposal
- Growing palm oil refining may increase PFAD availability, though sustainability concerns remain. While tall oil and technical corn oil are less viable, animal fats could offer a potential alternative.

Second
largest producer of sugarcane globally, as of 2024[6]

25.5 MMT
Vegetable oils consumed across India in 2024-25[7]



Strategic initiatives supporting green fuel transition

India's biofuel ecosystem and diverse feedstock availability provide a strong foundation for SAF development. Realising this potential requires coordinated support from all stakeholders. Government and industry-led initiatives are advancing the SAF transition through policy formulation, pilot projects and strategic collaborations. These efforts reflect growing momentum to integrate SAF into India's aviation sector. However, many of these initiatives remain in their early stages, underscoring the need for accelerated action to drive meaningful progress.

SAF mandates

India has set phased SAF blending targets for international flights, starting with a 1 per cent blend by 2027, increasing to 2 per cent by 2028 and reaching 5 per cent by 2030, as part of its broader strategy to decarbonise aviation[8]

Bio-aviation turbine fuel (ATF) programme

The Ministry of Petroleum and Natural Gas (MoPNG) formed a committee to steer the Bio-ATF programme, focusing on cleaner aviation fuels. Its role includes evaluating feedstock availability, relevant technologies and examining the impact of engine performance[9]

Uttar Pradesh SAF Manufacturing Promotion Policy 2025

Uttar Pradesh is set to launch India's first SAF-focused policy to establish the state as a manufacturing hub for SAF. With investment commitments exceeding USD340 million*, the policy is drawing significant interest from industry participants[10].

*The currency has been converted as per the conversion rate of USD1 = INR88.12 as of 28 October 2025

Industry strategy and airline-driven efforts

Widespread adoption of ATJ technology

Multiple companies are committing to the ATJ route for SAF production. This method is being prioritised due to its compatibility with India's abundant renewable feedstocks. The focus is leveraging agricultural by-products and industrial waste to create a sustainable and scalable fuel alternative.

Development of SAF infrastructure across key locations

A strategic partnership between a global SAF technology provider and a leading Indian energy company is driving large-scale SAF production in India. Pilot operations are underway in western India, with expansion progressing in the south. Plans include a full-scale commercial facility with a projected annual capacity of 20-30 million gallons, marking a major milestone in the country's efforts to decarbonise aviation.

Airline engagement with SAF

Airlines in India are beginning to explore SAF integration into their operations, with early-stage efforts focused on understanding and aligning with international frameworks such as CORSIA. This signals a shift towards cleaner aviation practices and a growing interest in sustainable fuel procurement.

KPMG in India analysis

Realising the potential of SAF in India

India has begun laying the groundwork for scaling SAF through targeted initiatives such as policy development, pilot projects and industry collaboration. These efforts not only help reduce aviation emissions but also promote environmentally conscious travel. As the benefits of sustainable fuels become increasingly evident, they are anticipated to drive further sector growth. Beyond lowering CO_2, the expansion of SAF offers wide-ranging benefits for India, including the creation of green jobs, boosting farmers' incomes and improving waste management.

Moreover, the commercialisation of by-products such as biochar, combined with enhanced national self-sufficiency, further strengthens the case for SAF. With a growing aviation market, abundant feedstock availability and a thriving ethanol ecosystem, India is well-positioned to emerge as a leading SAF producer.

Emerging as a key export hub

India has the feedstock capacity to potentially produce between 19 to 24 million tonnes of SAF annually, more than double the estimated domestic demand of 8 to 10 million tonnes by 2030, assuming a 50 per cent blend scenario. This surplus production capacity, combined with India's strategic geographic location, presents valuable opportunities to export SAF to neighboring regions such as Southeast Asia and the Middle East[11].

Reducing import dependence

India's crude oil imports reached 88.2 per cent during FY25, making it highly vulnerable to global oil price fluctuations, supply chain disruptions and geopolitical tensions. SAF production from domestic bio-resources reduces reliance on fossil fuels and enhances energy independence[12].

Driving inclusive growth

With just a one per cent SAF blend into conventional jet fuel, its production could positively impact over half a million farmers who supply sugarcane as a feedstock. Additionally, it could generate approximately 100,000 green jobs across the value chain, from feedstock collection and processing to logistics and refinery operations[11].

Accelerating green airport revolution

SAF can support green airport initiatives not only by supplying cleaner fuel and reducing aviation-related emissions but also by fostering the development of environmentally responsible airport infrastructure, such as energy-efficient terminals, green logistics and low-emission ground operations.

Attracting capital inflows

With a booming aviation market and strong government backing, SAF can drive investment into next-generation infrastructure. This includes the development of advanced biorefineries and the scaling of cutting-edge research and development in fuel technologies, feedstock innovation and carbon capture integration.

Overcoming barriers to SAF adoption

SAF presents a transformative opportunity for India to lower carbon emissions in aviation, reduce reliance on imported fossil fuels and stimulate rural development and green jobs. However, despite this potential, SAF production and deployment face considerable economic, technological and logistical challenges. These limitations could affect scalability and raise concerns about SAF's long-term role in supporting the aviation sector's climate objectives.

Challenges	Approaches
High production cost According to IATA, globally SAF is three times costlier than conventional jet fuel, making widespread adoption financially challenging for airlines. For airlines in India, which typically operate on narrow profit margins and face intense price competition, this steep cost differential presents a serious obstacle to adoption.	• Offer targeted financial interventions such as subsidies, tax credits and concessional loans • Establish carbon pricing and credit trading mechanisms • Promote green financing instruments • Encourage long-term offtake agreements.
Gradual evolution of technical expertise and industrial readiness India is still in the early stages of developing advanced SAF refining technologies, which makes large-scale production technically complex. High-tech processes such as ATJ and FT require high capital investment, R&D support and skilled manpower, slowing industrial readiness.	• Establish dedicated SAF research centres • Facilitating international technology transfer agreements • Launch skill development programs • Create incentives for startups and MSMEs.
Infrastructural gaps in manufacturing and blending SAF production demands significant investment in physical infrastructure. At present, India is working towards establishing biorefineries and advanced blending facilities capable of processing diverse feedstocks at scale. Existing refineries are primarily designed for conventional fuels and would need significant adaptation to accommodate bio-based materials such as agricultural residues, municipal solid waste and used cooking oil.	• Upgrade existing refineries and establish SAF-specific industrial clusters • Establish green corridor for SAF logistics • Develop regional SAF blending hubs • Create SAF infrastructure development schemes.
Supply chain bottlenecks While India possesses abundant biomass, scaling SAF production requires a well-integrated and reliable supply chain. Seasonal fluctuations, logistical inefficiencies and competition with food crops often disrupts the quality of feedstock availability. Additionally, the lack of robust collection systems for agricultural residues and used cooking oil limits feedstock availability.	• Develop dedicated SAF feedstock zones, contract farming models and waste-to-fuel initiatives • Establish regional biomass aggregation centres • Implement robust used cooking oil collection systems • Deploy digital tools for SAF supply chain monitoring and forecasting.

05

Advancing SAF in India and the path ahead

A strategic blueprint for scaling SAF in India

India encounters a range of challenges in advancing SAF adoption, including constraints related to feedstock sourcing, infrastructure readiness and policy alignment. These factors reflect the multifaceted nature of SAF deployment and the need for a structured approach. Addressing these complexities requires more than isolated efforts; it demands a cohesive, forward-looking blueprint that aligns stakeholders, mobilises resources and leverages India's unique strengths.

The following strategic framework outlines a roadmap to unlock SAF's potential through coordinated efforts in policy transformation, infrastructure development and financial innovation. It aims to build a resilient and scalable SAF ecosystem that aligns with India's long-term vision for cleaner aviation.

Strategic collaboration and policy enablement

- Aviation authorities can create a comprehensive framework to accelerate SAF deployment. This framework can include clear policy directives, developmental plans and mechanisms for efficient integration across the aviation value chain
- To encourage cost-effective SAF adoption, targeted policy instruments such as fiscal incentives, subsidies and carbon offsetting mechanisms can be introduced, supporting consistent progress across the aviation sector.

Expanding blending mandates

- Developing robust, long-term blending mandates is essential to scale SAF in India. Currently limited to international flights, these mandates can be progressively extended to domestic operations to enable broader sectoral adoption
- Setting clear, phased targets can offer policy certainty required for long-term planning, attract private investment, stimulate innovation and support the infrastructure development necessary for a sustainable aviation ecosystem.

Making SAF cost competitive

- With SAF currently priced two to five times higher than CAF, strategic interventions could help improve its competitiveness[1]. Large-scale or pioneering offtake agreements can offer producers the financial certainty needed to scale up operations.
- Introducing a price corridor, stabilised through instruments such as options and puts, can help manage volatility in this emerging market. By contractually sharing production risks, airlines may be able to negotiate lower SAF prices while building stronger supplier relationships.

Mobilising rural India as a feedstock engine

- Empowering rural communities and women self-help groups (SHGs) to become active participants in the SAF supply chain by collecting, sorting and preprocessing raw feedstocks
- By integrating SAF feedstock collection into existing rural livelihoods and waste systems, India can not only mitigate environmental pollution but also align SAF production with other national goals such as rural development and women empowerment, while ensuring that the energy transition remains inclusive.

Energy sector engagement

- Indian oil companies can invest in diverse technological pathways such as ATJ, FT and HEFA to accelerate SAF production. Upgrading existing refinery infrastructure to enable SAF co-processing and conducting blend trials with airlines can help validate performance and ensure regulatory compliance
- Additionally, aligning with sustainability standards and raising awareness among airlines can drive demand and ensure long-term viability.

Strengthening airport infrastructure

- Airports can invest in infrastructure specifically designed to support SAF, facilitating compatibility with existing fuelling systems. This includes upgrading distribution mechanisms such as dedicated storage facilities and SAF-compatible pipelines to enable efficient handling and delivery
- Establishing green corridors between major airports can promote consistent SAF usage across high-traffic routes, signalling commitment and enabling economies of scale for SAF producers and suppliers.

Aligning with global frameworks

- Harmonising India's policies with global sustainability frameworks through partnerships with international bodies such as ICAO and the International Renewable Energy Agency (IRENA) can help ensure consistent and credible policy development
- These collaborations provide India with access to global expertise, technical know-how and established practices. They can also open pathways to climate finance, enabling investment in clean technologies, infrastructure upgrades and capacity building.

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