SAF सामर्थ्य
‘Samarthya’

The opportunity of AtJ SAF in India

September 2025

ICF | 20 years in India

SAF ASSOCIATION

Foreword

Dr. Vasudevan S

Head of Aviation, Travel and Tourism (India & APAC), ICF

The aviation industry is entering a decisive decade from a decarbonization perspective. With net-zero targets on the horizon, the urgency to implement projects and deliver on green commitments has never been greater. Among the range of decarbonization levers, Sustainable Aviation Fuel (SAF) has emerged as one of the most immediate and scalable solutions from recent international experience—reducing lifecycle emissions while leveraging existing infrastructure and operations. Globally, momentum is building; many governments in the UK, EU and US have set mandates and provided incentives for aviation stakeholders to produce and consume SAF. Many airlines are firming up long-term offtake agreements, and technology providers are accelerating innovation, not just driven by policy but in many cases motivated by genuine interest in promoting economic growth and social welfare, by transitioning to cleaner fuels.

India, as the fourth largest economy and one of the fastest growing aviation markets in the world, stands at a pivotal juncture in its sustainable aviation journey. In a price sensitive and regulated market, the country faces both a challenge and an opportunity: to secure affordable, reliable access to SAF while also positioning itself as a leader in production, innovation, and regional supply. Our government has declared its firm commitment to decarbonize aviation and has set SAF blending targets in motion. To achieve these targets requires major stakeholders in the value chain – airport operators, airlines, oil companies, regulators and the government - to work unison. What India needs urgently is a roadmap for SAF that sets the blueprint for SAF production and uptake with a robust policy framework that not just makes all stakeholders key custodians of the transition to SAF but also active participants in enabling the transition from conventional ATF to greener fuels. The India SAF Conclave & Awards 2025 presents a timely and pioneering platform to unite policymakers, industry leaders, and innovators in charting a practical and collaborative roadmap for scalable SAF adoption.

At ICF, we have long worked at the intersection of policy, industry, and innovation to support the aviation sector in meeting its sustainability goals. Our collaboration with the SAF Association and the release of ***"SAF-समर्थ (Samarthya)"*** reflect our ongoing commitment to enabling data-driven strategies, robust economic modelling, and actionable insights that can translate ambition into impact.

We hope this knowledge paper serves not only as a reference point for stakeholders, but also as a catalyst for dialogue, partnerships, and collective action. Together, we can ensure that India does not just participate in the global SAF transition but helps shape it—emerging as a key driver of innovation, investment, and leadership in the journey toward a sustainable aviation future.

Foreword

Mr. Jimmy Olsson

President, SAF Association

India's civil aviation sector is soaring to new heights, poised to become one of the largest in the world. As we advance, it is peremptory to ensure our growth aligns with global sustainability goals and we can spearhead more ambitious targets for climate action as well.

Key initiatives like carbon neutrality targets, green energy integration, carbon accreditation for major airports, and support for SAF awareness by Ministry of Civil Aviation is promotion adoption of SAF.

SAF is currently more expensive than conventional fuel, production volumes are low, and there is a lack of supporting infrastructure and regulatory clarity. Feedstock availability and scalability are also concerns. However, India has a unique opportunity due to its abundant agricultural waste, low-cost renewable energy, and growing aviation market. If addressed strategically, these challenges could transform into advantages, positioning India as a major global SAF hub.

To lead in SAF, India must develop a national roadmap with clear targets, invest in production and storage infrastructure, and create strong public-private partnerships. Government incentives, a dedicated SAF consortium, support for R&D, and sustainable feedstock policies will be essential. With coordinated efforts, India can not only meet its climate goals but also drive economic growth and innovation, establishing itself as a global leader in clean aviation fuel.

Foreword

Mr. Vijay Nirani

Senior Vice President, SAF Association

India's civil aviation sector is experiencing unprecedented growth. With rising incomes, increasing connectivity, and government initiatives, the country is on track to become the third-largest aviation market globally. As the country advances toward this aviation boom, sustainable aviation fuel (SAF) is emerging as a critical lever to align growth with global climate goals. Sustainable Aviation Fuel (SAF) has emerged globally as the most promising solution to decarbonise aviation in the near-to-mid-term—and India has the potential to lead.

For SAF producers, this transition represents both a transformative opportunity and a complex challenge. India has already laid the groundwork for a bio-based future with the National Policy on Biofuels (NPB), revised in 2018 and updated in 2022, which aims to promote the production and use of biofuels across transport sectors.

SAF producers recognise that India holds several natural advantages that could make it a global leader in SAF production like abundant feedstock and agricultural waste, low-cost renewable electricity, large and fast-growing domestic aviation market and Emerging R&D institutions and public-private innovation platforms that can localise technology and drive cost reductions.

Together, government and industry can transform India's aviation sector into a model of sustainable growth, innovation, and climate leadership. With a strategic push, India can not only decarbonise its aviation sector but become a regional and global hub for SAF innovation and exports.

Foreword

Dr. Ajay Mathur

Mentor, SAF Association
Former DG, International Solar Alliance (ISA)

India has the potential to become a net exporter of sustainable aviation fuel (SAF), thanks to its abundant agricultural residue and expanding aviation sector. With aviation contributing 2%–3% of global carbon emissions, SAF is seen as a key solution to reduce the industry's environmental impact. However, supply remains a major challenge, as SAF currently costs 2.5 to 3.5 times more than conventional jet fuel.

India benefits from a strong feedstock base, including used cooking oil, farm waste, and agricultural residues that don't compete with food production. Developing the SAF sector could help India meet its climate goals while also boosting rural economic growth and enhancing energy security.

The Indian government, through the National Biofuel Coordination Committee (NBCC), is promoting sustainability in aviation by setting initial SAF blending targets. Biofuels are gaining traction due to their environmental advantages and the availability of organic raw materials like vegetable oil and biomass. This policy push is aligning with India's broader renewable energy goals.

Western and central regions, particularly cities like Mumbai, Pune, and Ahmedabad, are emerging as key SAF hubs. Strong infrastructure investment, government subsidies, and collaboration between airlines, fuel producers, and research bodies are accelerating SAF adoption. With growing air travel demand and a supportive policy environment, India’s SAF market is poised for significant growth and global leadership.

Foreword

Mr. Rohit Kumar

Secretary General, SAF Association

India's aviation sector is witnessing unprecedented growth, with passenger numbers and air cargo volumes rising year after year. While this growth is a sign of progress, it also brings with it a pressing challenge—our continued dependence on fossil-based jet fuels. This dependency not only exposes us to the risks of international price volatility but also locks us into carbon-intensive operations at a time when the world is moving towards net zero.

The need for Sustainable Aviation Fuel (SAF) in India is both urgent and undeniable. SAF is not just a cleaner fuel—it is a strategic opportunity to decarbonize one of the hardest-to-abate sectors, reduce our reliance on imports, and create new avenues for rural prosperity and green jobs.

It is with this vision that the Sustainable Aviation Fuel Association (SAFA) has been established. Our mission is clear: to bridge the existing gaps and accelerate India's SAF transition. We are committed to driving efforts on multiple fronts—establishing domestic production capacities, working with policymakers to design enabling frameworks, and developing market-based incentives that ensure SAF becomes a viable and mainstream alternative.

The Association is actively working to mobilize investments, foster R&D collaborations, and forge strategic partnerships between industry, government, and academia. Beyond decarbonization, SAF represents a transformative opportunity to strengthen India's rural economy by tapping into agricultural residues, energy crops, and waste streams, thereby creating inclusive growth models.

We believe India has the raw materials, the technological know-how, and the entrepreneurial spirit to build a thriving SAF ecosystem. What is required now is the collective will—commitment, collaboration, and bold decision-making. I hope these deliberations from the SAF Conclave will prove to be fruitful in forging future partnerships.

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1 Executive Summary

The aviation sector is under growing pressure to reduce emissions as climate targets tighten and international regulations advance. Sustainable Aviation Fuel (SAF) is the most practical near- and mid-term solution for large-scale decarbonization. The SAF landscape is rapidly evolving, with IATA estimating that global SAF production has doubled from 0.5 million tonnes (mt) in 2023 to 1.0 mt in 2024 and will double again to 2.0 mt over CY2025. ICF forecasts the industry will continue this rapid growth, increasing tenfold to slightly under 20 mt by 2030. This expansion creates opportunities for decarbonization, energy resilience, and job creation, but also risks for regions that fail to build competitive industries or implement effective regulation.

India's domestic SAF industry is still in its early stages of development. However, the Government of India has already approved indicative SAF blending percentages of 1% by 2027, rising to 5% by 2030 (initially for international flights), providing a clear signal to industry and investors. The estimate volume for meeting the 5% blending requirement in 2030 is about 700 million litres. This milestone offers a strong starting point to accelerate market creation and build investor confidence. Leveraging this momentum, India has an opportunity to deploy SAF at scale by capitalizing on its ethanol ecosystem, developed through the Ethanol Blending Programme (E20). This foundation of feedstock supply, production capacity, and policy experience can be redirected toward Alcohol-to-Jet (ATJ) SAF, a pathway uniquely compatible with existing ethanol infrastructure and aligned with aviation's decarbonization needs. Leading oil companies such as the Indian Oil Corporation (IOCL), Bharat Petroleum Corporation Limited (BPCL) and other SAF producers such as Praj Industries, TruAlt Bioenergy, Avaada Group among others are investing in capacity and technology to meet both domestic and export demands for SAF.

In our view, the Alcohol-to-Jet (AtJ) pathway offers the best alignment with India's ethanol economy, public-private R&D ecosystem, and policy vision for a circular bioeconomy. It creates a scalable, sustainable SAF production model rooted in domestic agricultural residues, industrial by-products, and sugar sector overflows. With its high feedstock flexibility, backward integration potential with 2G bioethanol plants, and relatively lower infrastructure risk, AtJ can emerge as the primary SAF deployment pathway for India over the next decade[1].

In addition to its policy fit, AtJ delivers significant adjacent benefits. It can generate rural jobs through biomass collection and ethanol production, while enabling decentralized SAF production clusters near feedstock hubs. These features collectively strengthen India's competitiveness in the evolving global SAF landscape.

Scaling Alcohol-to-Jet (AtJ) Sustainable Aviation Fuel (SAF) production in India would significantly improve the nation's energy security and reduce its reliance on fossil fuel imports. The transition would also boost rural incomes by using agricultural feedstocks. After meeting domestic demand, India could

[1] While this paper focuses on an established and widely implemented pathway for SAF production, India has the opportunity to also leverage its ability in producing SAF from other types of feedstock including, HEFA, UCO, Power-to-Liquid (PtL) or the Fischer-Tropsch process using biomass, MSW, green hydrogen for producing e-SAF

position itself as a regional exporter to markets with binding SAF requirements, helping the country meet its aviation emissions targets and become a leader in sustainable aviation.

To capitalize on this opportunity and ensure aviation emissions targets are met, the following strategic recommendations are proposed.

Table 1. Key Recommendations

Focus Area	Recommendations
AtJ SAF Scale-Up	• Leverage India's ethanol ecosystem and 2G ethanol infrastructure to accelerate AtJ SAF production • Enable flexible feedstock use, including surplus ethanol and biomass, while maintaining alignment with E20 fuel mandates
Infrastructure & Technical Capabilities	• Upgrade airport and Oil Marketing Company terminal infrastructure for SAF storage, blending, and distribution • Conduct national-level mapping of SAF-compatible feedstocks (ethanol, biomass, Used cooking oil (UCO), Municipal Solid Waste (MSW), CO_2) • Develop targeted skill-building programs for SAF production, logistics, and industry-academia platforms.
Financial Incentives	• Extend Viability Gap Funding (₹150 crore/project)* and production-linked incentives • Provide CAPEX subsidies, tax incentives, or low-interest financing to reduce capital barriers
Institutional & Logistical Enablers	• Repurpose existing Oil Marketing Company networks and airport infrastructure to streamline SAF integration • Foster inter-ministerial coordination across civil aviation, energy, agriculture, and industry • Utilize digital platforms for supply chain monitoring, certification, and reporting

2 Introduction

In 2025, air transport contributed USD 53.6 billion to India's GDP (approximately 1.5%), supported 7.7 million jobs, and directly employed nearly 370,000 people in airlines, airports, manufacturing, and air navigation services.[2] As a result, India has become the world's third-largest aviation market, handling an estimated 174 million passengers travelling from and within the country annually.[3]

Despite accounting for nearly 18% of the global population, India currently represents only 4.2% of global origin-destination (O-D) departures, underscoring the vast runway for growth. As airport infrastructure expands and fleet sizes continue to double, India's aviation market is poised for sustained, long-term expansion.[4]

However, this growth trajectory is intrinsically tied to increased jet fuel demand and carbon emissions. Decarbonising aviation in India is therefore not only a climate imperative, but it is also a strategic opportunity to build domestic resilience, reduce energy imports, and catalyse a low-carbon fuel industry aligned with India's broader energy transition.

Recognizing this, India launched the SAF Alliance in February 2025 to accelerate production and adoption of Sustainable Aviation Fuels.[5] The initiative represents a significant step in efforts to reduce aviation emissions, with ambitious targets of 1 percent SAF blend by 2027, 2 percent by 2028, and 5 percent by 2030.[6]

These **indicative blending percentages** create a predictable pathway for ramping up SAF supply, offering policy certainty for industry players while advancing national climate goals.

A series of early SAF milestones has already signalled India's readiness to move from ambition to action. Praj Industries, in partnership with LanzaJet, has commissioned a 1 kilolitre per day AtJ demonstration facility in Pune, pioneering domestic SAF production.[7] In 2023, Praj and Indian Oil successfully powered a commercial flight from Pune to Delhi with an indigenously produced SAF blend.[8] Building on this success, Indian Oil and other Oil Marketing Companies (OMCs) are now actively developing SAF production capacity to meet indicative blending percentages beginning in 2027.[9] Alongside this, several 2G ethanol plants by IOCL, BPCL, and HPCL (e.g., Panipat, Bathinda, and Bargarh) are either operational or under commissioning, creating a ready supply of ethanol feedstock for SAF pathways. Private players such as TruAlt Bioenergy are also preparing scaled-up deployments, reinforcing the public-private alignment behind SAF. These developments demonstrate both industrial momentum and policy-driven confidence in a domestic SAF industry.

However, the critical constraint to large-scale deployment of SAF in India is the certification and regulatory approval process, particularly compliance with ASTM D7566 — the globally mandated standard for blending SAF into commercial aviation fuels. The certification pathway to approval is both cost- and time-intensive, requiring extensive testing for fuel properties, compatibility with existing aviation infrastructure, and Original Equipment Manufacturer (OEM) validation. On average, the

[2] https://www.iata.org/en/iata-repository/publications/economic-reports/the-value-of-air-transport-to-india/
[3] https://www.iata.org/en/iata-repository/publications/economic-reports/the-value-of-air-transport-to-india/
[4] https://www.iata.org/en/iata-repository/publications/economic-reports/aviation-in-india/
[5] https://www.millenniumpost.in/business/india-saf-alliance-launched-to-propel-sustainable-aviation-energy-goals-597582#google_vignette
[6] https://apps.fas.usda.gov/newgainapi/api/Report/DownloadReportByFileName?fileName=Biofuels%20Annual_New%20Delhi_India_IN2025-0031.pdf
[7] https://ethanolproducer.com/articles/praj-inaugurates-saf-demonstration-facility-in-india
[8] https://www.praj.net/wp-content/uploads/2023/05/230519-Press-Release-Praj-IOCL-AirAsia.pdf
[9] https://www.100knots.com/air-india-partners-with-indian-oil-in-landmark-sustainable-aviation-fuel-agreement/

qualification cycle spans 12–18 months and can cost several million dollars, creating a significant entry barrier for new producers.

Despite these challenges, India has made encouraging progress. Indian Oil Corporation Limited (IOCL) became the first domestic player to secure **ISCC-CORSIA certification** at its Panipat refinery recently, with a target of producing 35,000 tonnes of SAF by 2025.[10] Parallelly, the **Council of Scientific and Industrial Research – Indian Institute of Petroleum (CSIR–IIP)** in Dehradun has developed an indigenous HEFA process, which has already received **provisional clearance from the Indian Air Force (CEMILAC/IAF)** and is currently under evaluation by ASTM.[11] This milestone demonstrates India's ability not only to adopt but also to innovate SAF pathways domestically. These developments underscore that SAF in India has already moved beyond policy ambition into practical reality. A critical next step is identifying the most scalable and strategically suited SAF opportunities for India. Among the various SAF production pathways (HEFA, Fischer-Tropsch, Power-to-Liquids), AtJ stands out. It builds directly on India's established ethanol ecosystem, taps into both first- and second-generation feedstocks, and offers a pathway uniquely positioned to deliver on India's aviation decarbonization targets.
This makes AtJ not just a viable option, but arguably the most strategic pathway for scaling SAF in India by 2030.

3 What is Alcohol-to-Jet (AtJ) SAF?

SAF can be produced through multiple technology pathways, including Hydro processed Esters and Fatty Acids (HEFA), Fischer-Tropsch (FT), Alcohol-to-Jet (AtJ), and Power-to-Liquids (PtL). Each pathway uses different feedstocks and conversion processes[12] but produces a fuel that is fully compatible with existing aircraft and infrastructure.

Today, HEFA is the only SAF pathway deployed at commercial scale, primarily using waste oils, fats, and greases. However, HEFA feedstocks are limited and face competing demand from other sectors. Scaling aviation decarbonization requires diversification into other pathways such as AtJ, which can utilise more abundant feedstocks.

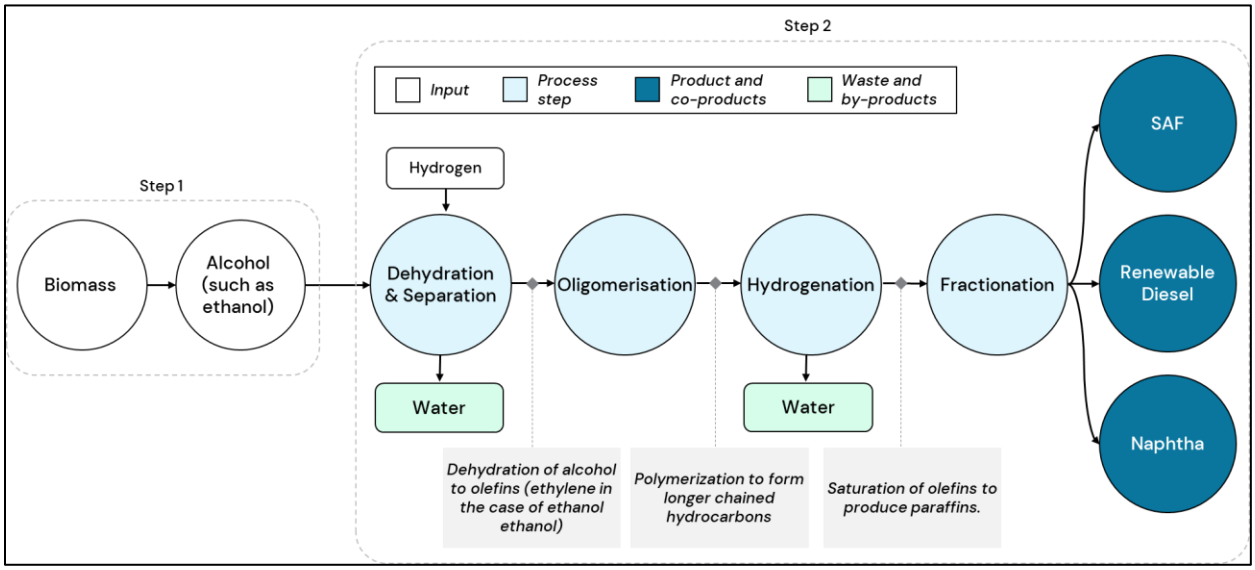
For India, AtJ stands out for its strong alignment with India's existing feedstock sources existing ethanol ecosystem. It converts ethanol (or other alcohols) into jet fuel through a proven catalytic process. AtJ is already ASTM-certified[13] for aviation use and has reached technology readiness levels (TRL) 7–8[14], meaning it is close to full commercial deployment.

[10] https://timesofindia.indiatimes.com/business/india-business/cooking-oil-to-aviation-fuel-indianoils-panipat-refinery-bags-global-certification-35000-tonnes-saf-production-targeted-by-year-end/articleshow/123342719.cms
[11] https://www.pib.gov.in/PressReleasePage.aspx?PRID=1776193
[12] See Appendix
[13] ASTM International is the global standards body that tests and certifies aviation fuels. SAF pathways must meet ASTM D7566 specifications to ensure full safety, performance, and compatibility with existing aircraft and fuelling infrastructure. Once certified, SAF can be blended with conventional jet fuel and used in commercial flights.
[14] TRL is a scale from 1–9 used to assess technology maturity. TRL 7 indicates system prototype demonstration in an operational environment, while TRL 8 means the system is complete and qualified. AtJ SAF at TRL 7–8 has already been demonstrated at industrial scale and is ready for broader commercialization.

3.1 How is AtJ SAF produced?

AtJ follows a two-step process: (1) biomass to ethanol, (2) followed by ethanol to SAF, as outlined below.

Figure 1. AtJ Process



3.2 What are the key strengths of AtJ SAF?

A defining strength of AtJ is its feedstock flexibility, as it can use both first-generation ethanol (produced from sugarcane, corn, or grains) and second-generation ethanol (produced from crop residues such as rice straw, wheat straw, or bagasse). This versatility allows India to leverage a wide range of locally available raw materials while reducing reliance on any single commodity. Importantly, the ability to use 2G ethanol addresses concerns around food-versus-fuel competition, enabling waste-based feedstocks that are often burned in the open, contributing to severe air pollution, to be converted into high-value, low-carbon fuel. This creates a dual benefit of improving environmental outcomes while supporting rural livelihoods through decentralized biomass sourcing. Each 100 Kilolitre per day plant generates 120 direct jobs (40 skilled, 80 semi-skilled) and hundreds of indirect rural employment opportunities through biomass supply chains and logistics.

4 What is the opportunity for India?

The global push to diversify SAF technologies and feedstocks presents a timely and strategic opportunity for India. As demand for SAF accelerates worldwide and the limitations of traditional pathways become more apparent, countries with untapped feedstock potential, biofuel expertise, and emerging policy frameworks are well-positioned to support the growing demand for SAF supply.

India is also well poised to develop SAF production domestically through the following two characteristics.

4.1 An established biofuels ecosystem

India's Ethanol Blending Programme (EBP) increased the ethanol blending in petrol from just 1.5% in 2014 to 20% by March 2025, five years ahead of schedule.[15] This rapid progression was the outcome of carefully orchestrated policies, incentives, infrastructure development, and strategic planning that de-risked ethanol production and built resilient supply chains. The EBP's demonstrated success provides a strong blueprint for India's next energy transition in aviation fuels.

An Indian AtJ SAF industry could capitalize on the extensive ethanol ecosystem built through the EBP. A nationwide network of ethanol production, logistics, and blending capabilities, born out of supportive policies and industrial investments, can now be leveraged to lower both the marginal cost and the time needed to scale ATJ SAF production compared to countries starting from scratch. This positions India to accelerate adoption and gain a competitive advantage in the global SAF market.

India's ethanol production capacity grew nearly eight-fold from 1.7 billion litres in 2014 to 13.8 billion litres in 2023.[16] This exponential rise was underpinned by EBP blending mandates, price guarantees, production-linked incentives, and interest subvention schemes. Much of this existing capacity can either be harnessed directly for ATJ SAF or signal the potential for further growth through targeted SAF-related policies. Importantly, India can also leverage the existing Viability Gap Funding (VGF) of ₹150 crore per project under the Ministry of New and Renewable Energy's *National Bioenergy Programme Phase-II*, which currently supports 2G ethanol production. Since 2G ethanol is a key feedstock for ATJ, this financing mechanism effectively lowers investment barriers and accelerates the creation of SAF-ready supply chains.

Established Indian Oil Marketing Companies (OMCs), which played a vital role in the EBP, also provide a unique institutional advantage. By facilitating ethanol procurement, blending, and distribution across their nationwide depots and pipeline infrastructure, OMCs have already proven their ability to manage large-scale liquid biofuel integration. These same capabilities can be repurposed, complemented, and expanded to support ATJ SAF production and distribution, ensuring a seamless integration with India's energy logistics backbone.

4.2 A surplus of AtJ-compatible feedstocks

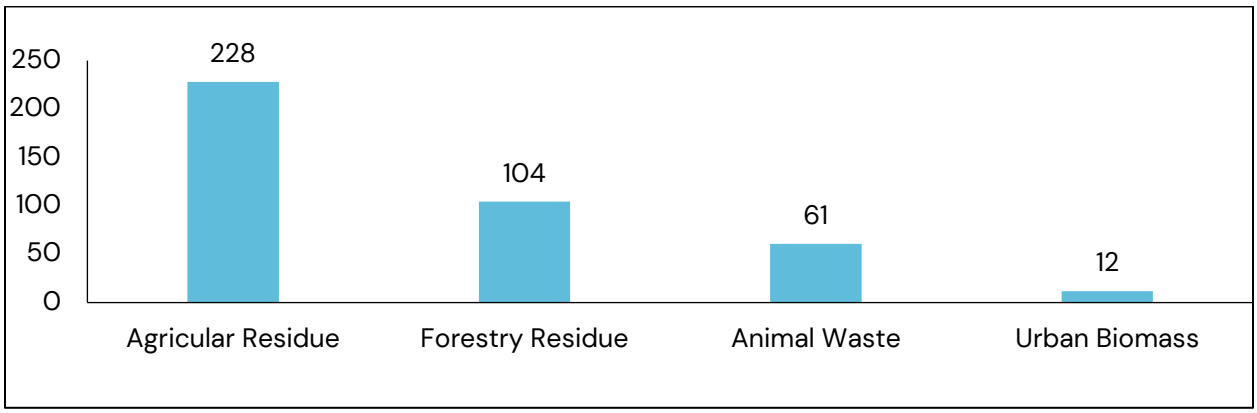
India possesses a vast and diverse biomass resource base, ranging from extensive agricultural residues and sugar industry by-products to waste oils, municipal solid waste (MSW), and fast-growing biomass like bamboo. An ICF analysis concluded that India produces approximately 754 million metric tons (mmt) of biomass annually from agricultural residues alone, of which nearly 228 mmt (30%) is identified as surplus, available for energy conversion after accounting for competing uses. Around 54 crops cultivated across India contribute to this biomass pool, however, about 70% is derived from just eight major crops (paddy straw, wheat straw, sugar bagasse, sugarcane trash, cotton stalks, groundnut shells, and coconut husks).

Beyond agricultural residues, India has several surplus biomass streams from forestry, animals, and urban biomass waste that can be harnessed, highlighting the diversified feedstock sources available to an Indian AtJ SAF industry. ICF estimates a significant surplus across these streams, as outlined in the following figure.

[15] https://apps.fas.usda.gov/newgainapi/api/Report/DownloadReportByFileName?fileName=Biofuels%20Annual_New%20Delhi_India_IN2025-0031.pdf

[16] https://apps.fas.usda.gov/newgainapi/api/Report/DownloadReportByFileName?fileName=Biofuels%20Annual_New%20Delhi_India_IN2025-0031.pdf

Figure 2. Available Surplus Biomass by Stream (million tonnes)



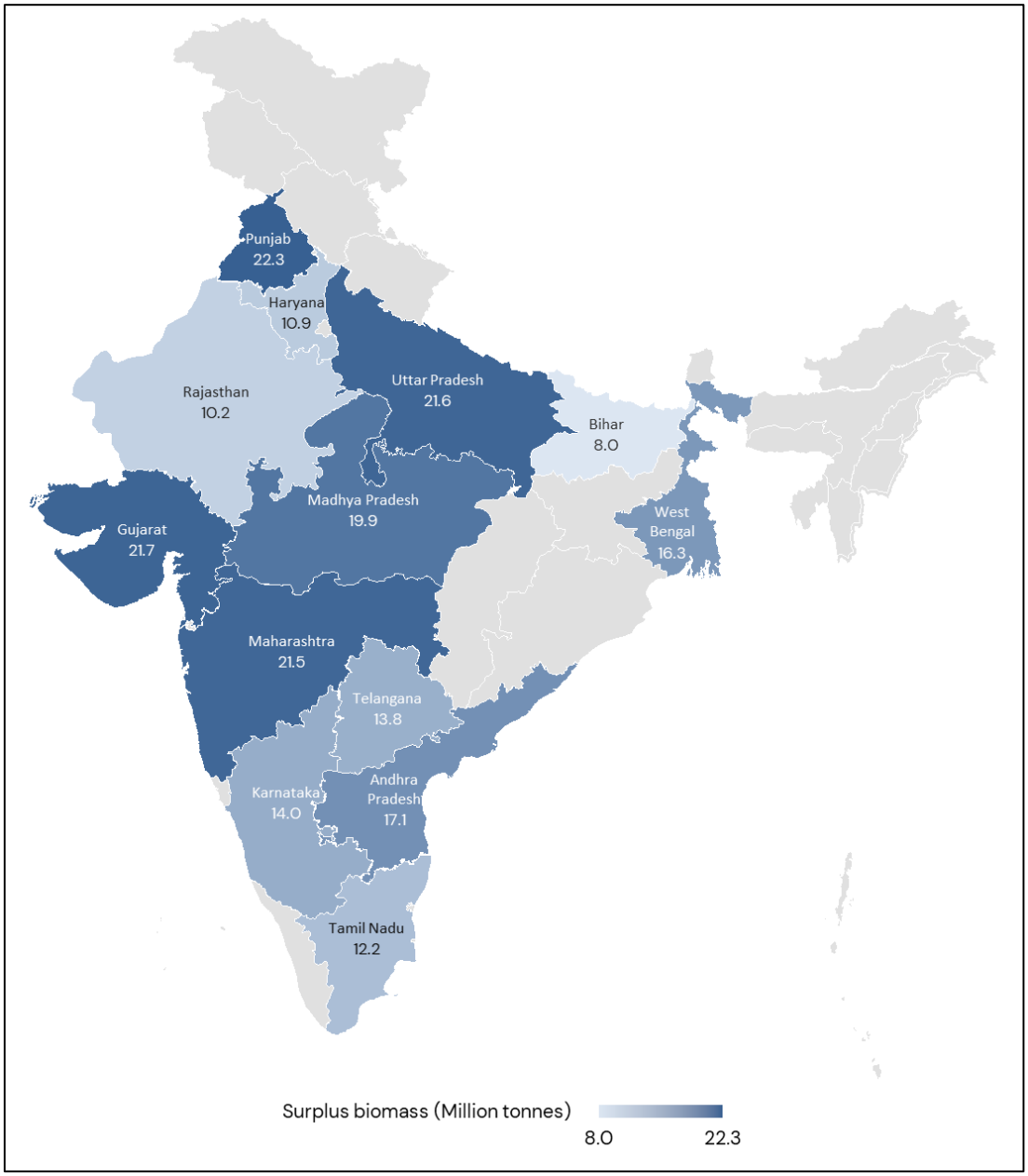
Key insights:

- **Agricultural Residues** account for the largest surplus at **228 mt**, indicating strong potential for large-scale bioenergy and biofuel initiatives.
- **Forestry Residues** offer a surplus of **104 mt**, presenting a reliable feedstock for industrial-scale biomass applications.
- **Animal Waste**, with a surplus availability of **61 mt**, is well-suited for decentralized biogas and CBG production, particularly in rural and dairy-rich regions.
- **Urban Biomass**, though smaller in quantity (**12 mt**), represents a strategic opportunity for urban waste-to-energy projects and integrated solid waste management.

This surplus of more than 400 mt of biomass remains even after accounting for the approximately 175–210 mt that gets utilised per year through various government schemes. The surplus of biomass sources is distributed across various regions and sectors. As outlined in Figure 3, the majority of the feedstock sources are concentrated in the following regions: Punjab, Madhya Pradesh, Uttar Pradesh, Gujarat, and Maharashtra. This supply is shaped by differences in agricultural intensity, industrial processing, and competing uses.

The spread of surplus volumes by states (from less than 1 mt to over 20 mt) highlights the importance of appropriate regional targeting for feedstock aggregation and SAF facility siting. With biomass generation increasing annually, the overall availability is expected to remain consistently high, ensuring long-term resource security for bioenergy initiatives.

Figure 1. Surplus Biomass Availability by Region in India



5 What is the economic viability of AtJ SAF production in India?

The economic viability of AtJ SAF in India is currently constrained by high production costs, estimated at an average of 3–5 times higher than conventional jet fuel. Feedstock costs represent the largest portion, at 50–70% of total costs, followed by capital expenditure for conversion plants (15–25%), operational costs (5–10%), logistics (4–10%), certification and sustainability compliance (1–2%), and other overheads (3–5%).

Table 2. Illustrative AtJ SAF cost break-down

Cost Category	% of total cost	Description and Key Drivers
Feedstock costs (ethanol)	50-70%	Cost of ethanol (1G or 2G) delivered to the AtJ plant, influenced by agricultural commodity prices, feedstock availability, and transportation costs.
Conversion costs (CAPEX)	15-25%	Capital expenditure for building the AtJ conversion plant, including reactors, separation units, and auxiliary systems. Highly dependent on plant scale and technology licensing fees.
Conversion costs (OPEX)	5-10%	Operational expenditure for the AtJ plant, including utilities (energy, water), catalysts, chemicals, labour, and maintenance.
Logistic costs (inbound ethanol)	2-5%	Transportation of ethanol from distilleries to the AtJ plant. Influenced by distance, mode of transport (road/rail), and volume.
Logistic costs (outbound SAF)	2-5%	Transportation of SAF from the AtJ plant to airport fuel farms. Influenced by distance, mode of transport (pipeline/truck/rail), and airport infrastructure.
Certification & sustainability costs	1-2%	Costs associated with ASTM certification, sustainability auditing, and compliance with regulatory standards.
Other overhead	3-5%	Administrative costs, R&D, insurance, and other miscellaneous expenses.

However, the benefits extend far beyond direct fuel price comparisons. AtJ SAF can achieve up to 90% lower lifecycle greenhouse gas emissions compared to fossil jet fuel, while enhancing energy security by reducing reliance on imported crude oil and mitigating exposure to global price volatility and geopolitical risks. Domestic SAF production also generates substantial local economic impact: each 100 kilolitres per day (KLPD) AtJ plant creates 120 direct jobs (40 skilled, 80 semi-skilled) and hundreds of indirect rural employment opportunities through biomass supply chains and logistics.

Scaling SAF production will require substantial capital investment and targeted financial incentives to attract private investment, which seem prudent and justified considering the value of benefits that would accrue over the next 25 years. Policy support is therefore critical to attract and de-risk private investment, through the following measures:

- **Production Incentives:** Direct subsidies, tax breaks, or production-linked incentives (PLI) to offset operational costs
- **Capital Subsidies:** Grants or subsidies for the initial setup of SAF plants
- **Viability Gap Funding (VGF):** Mechanisms to bridge the initial cost gap between SAF and conventional jet fuel
- **Low-Interest Loans:** Access to concessional financing from government-backed institutions
- **Blended Finance Approaches:** Combining public support, private equity, debt, and green bonds to lower overall investment risk

- **Dedicated Funding Mechanisms:** Establishment of a SAF specific fund or allocation from existing infrastructure funds to SAF projects
- **Export linked benefits:** Incentivising exports while ensuring sufficient production and supply of SAF to meet domestic demand.

Evolving global carbon pricing mechanisms, such as CORSIA and the EU ETS, offer additional revenue opportunities through carbon credits. A well-defined and liquid national framework for SAF carbon credit generation, verification, and trading would enhance financial predictability, improve access to financing, and offset a portion of the cost disparity with fossil jet fuel. While SAF remains more expensive than conventional jet fuel today, the combination of carbon revenue streams, energy security value, and targeted financial incentives can significantly improve the economic viability of AtJ SAF in India and support its large-scale commercialization and bring down the price of SAF for users over time.

6 Results and Recommendations

The remarkable progress of India's Ethanol Blending Programme (EBP) offers a blueprint for the successful rollout of SAF. By moving from 1.5% petrol blending in 2014 to 20% in 2025, the programme demonstrated that clear mandates, financial de-risking, and coordinated policy support can accelerate industrial transformation at scale.

For SAF to replicate this trajectory, India will need to adapt and extend some of the same guiding principles. Just as administered pricing and government-backed guarantees gave ethanol producers the security to expand capacity, SAF producers will require tailored financial instruments (such as long-term offtake agreements, targeted incentives, and price-support mechanisms) to justify capital-intensive investments. Similarly, the logistics innovations and aggregation networks developed under E20 to streamline feedstock supply can be expanded to encompass surplus biomass feedstock available for SAF production.

EBP's success also highlights the importance of institutional enablers. Oil Marketing Companies played a critical role in procurement and distribution, while digital platforms enabled credible monitoring of blending and emissions benefits. Repurposing these institutional capabilities for SAF can provide confidence to producers, investors, and regulators, while keeping compliance and traceability aligned with global carbon market requirements.

Equally important is governance: EBP benefitted from inter-ministerial coordination and consistent policy fine-tuning. Extending this collaborative model to SAF, bringing together civil aviation, energy, agriculture, and industry stakeholders, will be vital to remove bottlenecks, harmonize regulations, and accelerate deployment.

In short, the success of the EBP has created a tested framework of mandates, incentives, logistics, and governance that can be repurposed for aviation fuels. The EBP experience therefore, provides strong building blocks for the SAF industry, as outlined in the following recommendations.

Table 3. E20 Mandate vs. SAF Implementation

Dimension	E20 Ethanol Blending	SAF Implementation	Key Takeaway for SAF
Mandate Strength	Fixed, annually rising national targets	Nascent, gradual increase	Set clear, ramped blending mandates
Feedstock Base	Sugarcane, grains, multi-feedstock flexibility	UCO, agri-waste, MSW, non-edible oils, CO_2/H_2	Diversify early, incentivize aggregation networks
Price Mechanism	Administered price, government guarantees	Market-based, no floor price yet	Create price floors or subsidies for first movers
Producer Incentives	Viability gap, duty waivers, soft loans	Pilots only, limited fiscal support	Scale up production-linked incentives
Blending/ Distribution	OMC-driven, >250 depots, robust pipeline network	Airport-centric, fragmented logistics	Use existing OMC and airport infrastructure for SAF integration
Policy Coherence	Strong inter-ministry, regular revision	Developing, with Ministry of Civil Aviation anchor	Strengthen cross-ministry task forces
Certification	Digital traceability, auction-based supply	Nascent, batch-level, international plus voluntary MRV	Invest in digital SAF certification infrastructure
Market Depth	Domestic, scale guaranteed by mandate	Export-eligible, but dependent on global standards	Align SAF standards with export markets early on
Cost Competitiveness	Parity or lower vs. petrol (with subsidies)	2–5× costlier than jet-A1	Bridge initial gap with capital and operating expenditure incentives. Airports and economic regulators have an important role to play here to hasten adoption by airlines and passengers

7 India's Key Strategic Strengths:

1. **Surplus Ethanol Availability:** India currently produces over 500 crore litres of ethanol annually, a figure projected to increase significantly with the implementation of the E20 Ethanol Blending Programme. This surplus capacity provides a strong foundation for ethanol redirection into SAF production without compromising existing blending targets.
2. **Robust Aggregation & Distribution Infrastructure:** India's ethanol value chain is supported by a mature procurement and logistics ecosystem comprising over 250 ethanol depots, a well-functioning tender-based procurement system by Oil Marketing Companies (OMCs), and

extensive storage, transport, and blending infrastructure. These systems can be leveraged for ATJ feedstock handling, minimizing incremental capital requirements.

3. **Established 2G Ethanol Production Base:** India has made significant progress in deploying 2nd Generation (2G) ethanol plants that convert lignocellulosic biomass into ethanol using proven fermentation and pre-treatment technologies (TRL 8–9). Notable examples include:
   - IOCL's 2G ethanol plant in Panipat (100 KLPD)
   - HPCL's Bathinda facility (100 KLPD)
   - BPCL's Bargarh facility (100 KLPD): These facilities offer potential backward integration points for ATJ production from biomass, supporting both agricultural residue utilization and rural value creation.
4. **Emerging ATJ Pilots and Industry Readiness:** Several Indian companies are already engaged in ethanol-to-jet fuel technology development:
   - Praj Industries has commissioned a 1 KLPD ATJ demonstration plant in Pune, utilizing its in-house technology developed in collaboration with LanzaJet (USA).
   - TruAlt Bioenergy is planning a 15–20 KTPD ATJ commercial facility in Belagavi, Karnataka, using sugarcane ethanol as feedstock.
   - IOCL and CSIR–IIP are engaged in advanced R&D for catalytic conversion technologies specific to Indian feedstock conditions.
5. **Strong and growing aviation sector:** India will continue to be one of the fastest growing aviation markets in the world given its low air traffic penetration, increasing per capita incomes, more opportunities for global mobility and better air connectivity to global business and tourism destinations
   a. India has one of the largest aircraft fleets on order, expected to reach an operating fleet of around 1600 aircraft in 2030 and 2200 by 2035. This increase in fleet provides by far the biggest opportunity for SAF producers globally to meet the increasing demands for blending to meet long-term decarbonization goals.
   b. Growth of the domestic market, mandates for foreign carriers and higher SAF production volumes and more off-take agreements facilitated by policy will make the cost of SAF more affordable for domestic and international carriers
   c. Private airports aspiring to be future international hubs can support in subsidising SAF through innovating financing solutions, concessions for SAF infrastructure and reduction in aeronautical tariffs to attract traffic and make them preferred airport gateways.

8 Way Forward for India

Establish a National SAF roadmap

This roadmap must set clear blending targets, define eligible feedstocks, and outline fiscal and regulatory support mechanisms.

Launch a SAF Mission under Inter-Ministerial Task Force

A coordinated mission involving the Ministries of Civil Aviation, Petroleum & Natural Gas, Environment, Agriculture, and Industry can ensure policy coherence, streamline approvals, and unlock synergies across sectors.

Scale Up Demonstration Projects and Commercial Facilities:

Support for pilot plants and early commercial-scale ATJ facilities should be expanded through production-linked incentives, viability gap funding, and concessional financing.

Develop SAF Pricing and Market Support Mechanisms:

India should introduce price floors, carbon credits, and long-term offtake agreements. Airports and economic regulators can play a catalytic role by offering SAF-linked concessions and tariff reductions.

Align with Global Standards and Export Opportunities:

By meeting the requirements of international bodies like CORSIA and RSB, India can ensure its SAF is recognized globally, opening significant export opportunities and attracting foreign investment. This allows producers to participate in global carbon markets, where SAF can be sold at a premium.

Engage Airlines and Airports as Strategic Partners

Domestic and international carriers should be encouraged to sign SAF offtake agreements, while airports can be incentivized to invest in SAF infrastructure and offer preferential treatment to SAF-powered flights.

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SAF ASSOCIATION

ABOUT US

The SAF Association envisions a cohesive effort to drive investments, attract global partnerships, and embed sustainability into aviation and related sectors. Through short mid and long-term goals, this initiative seeks to achieve impactful results, from improving rural livelihoods to contributing significantly to India's Net Zero by 2070 ambitions. SAF represents more than a fuel—it's a catalyst for economic, environmental, and social transformation. This document is a call to action for stakeholders to join hands and create a sustainable future for aviation.

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