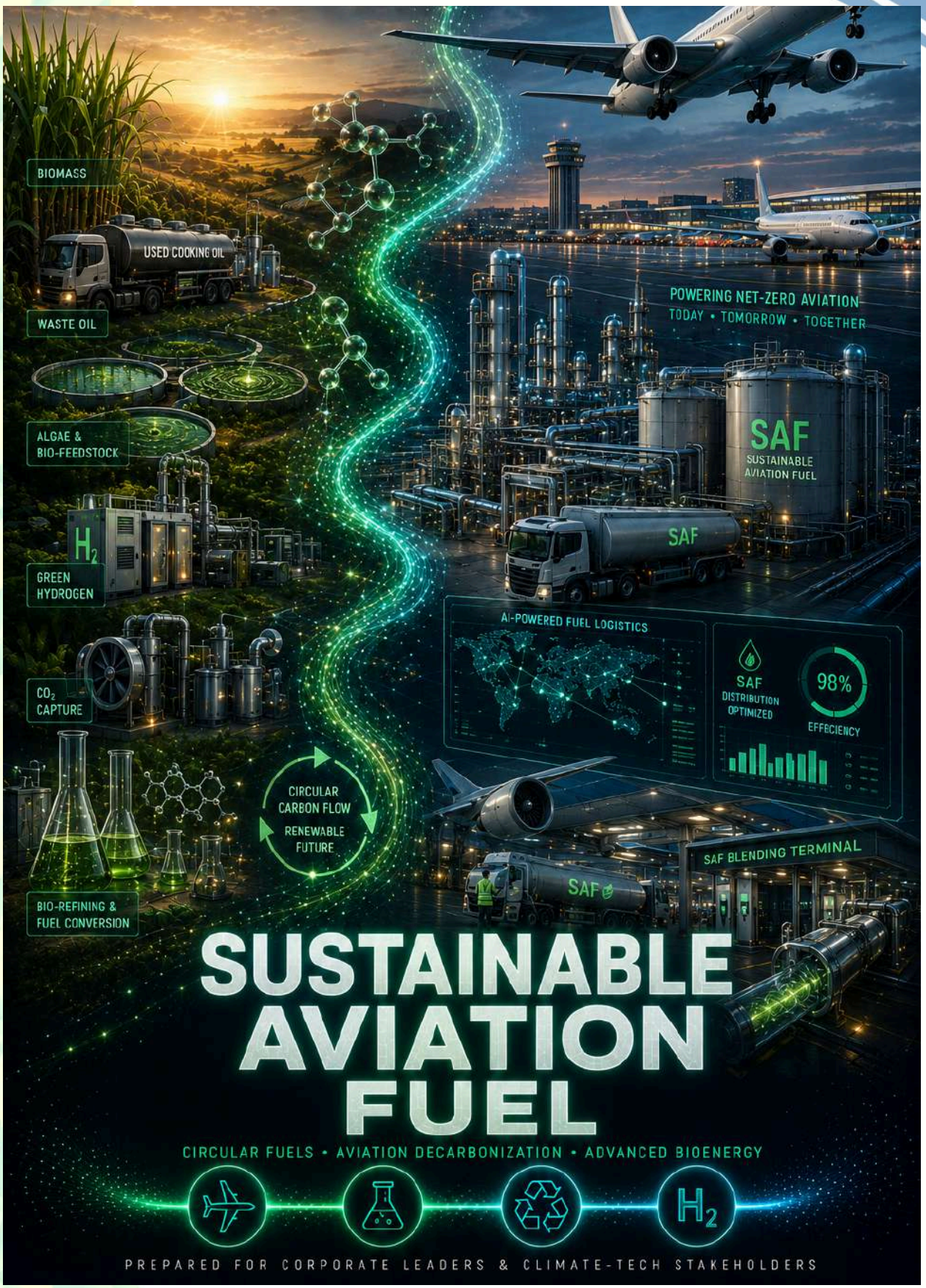
BIOMASS
USED COOKING OIL
WASTE OIL
ALGAE & BIO-FEEDSTOCK
$H_2$
GREEN HYDROGEN
$CO_2$ CAPTURE
BIO-REFINING & FUEL CONVERSION
CIRCULAR CARBON FLOW
RENEWABLE FUTURE
POWERING NET-ZERO AVIATION
TODAY • TOMORROW • TOGETHER
SAF
SUSTAINABLE AVIATION FUEL
SAF
AI-POWERED FUEL LOGISTICS
SAF DISTRIBUTION OPTIMIZED
98%
EFFECIENCY
SAF BLENDING TERMINAL
SAF
SUSTAINABLE AVIATION FUEL
CIRCULAR FUELS • AVIATION DECARBONIZATION • ADVANCED BIOENERGY
$H_2$
PREPARED FOR CORPORATE LEADERS & CLIMATE-TECH STAKEHOLDERS

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## *Bio Energy*

# *Sustainable Aviation Fuel*

*This section provides key inputs on the Indian Sustainable Aviation Fuel Opportunities for corporate leaders.*

## Highlights

- Massive structural demand growth driven by airline net-zero commitments, ICAO mandates, and emerging blending requirements
- Premium pricing environment as SAF commands green fuel premiums relative to conventional jet fuel
- Feedstock diversity opportunity (waste oils, agri residues, municipal waste, alcohol-to-jet pathways) enabling circular economy integration
- Strong policy and ESG tailwinds attracting climate finance, government incentives, and long-term offtake agreements

## Key recommendations for corporate leaders include:

- Invest in proven conversion technologies while maintaining flexibility for next-gen pathways
- Secure long-term airline and fuel offtake partnerships to guarantee revenue visibility
- Build feedstock aggregation ecosystems to stabilize input costs and plant utilization
- Design SAF projects as integrated circular platforms monetizing carbon credits and co-products.

# Opportunity Snapshot: Sustainable Aviation Fuel (SAF)

Low-carbon aviation fuel from biomass, waste oils, or synthetic (e-fuels)

## Market Signal

- Demand due to **airline decarbonisation**
- India exploring **blending targets (1-5%)** by 2030
- **Annual Market size by 2030:** 1000 - 2000 ₹ Cr

## What Makes or Breaks It?

- **Access to sustainable feedstock** (oils, agricultural residues)
- Ability to achieve **cost competitiveness** vs jet fuel ( scale+tech efficiency )
- Long-term offtake agreements with airlines ensuring revenue visibility

## Why It Matters NOW?

- Aviation, a hard to abate sector, contributes **2-3% of emissions globally**
- Secured future demand, as industry committing to **net zero by 2050**
- **Early mover advantage**; lock in long-time supply contracts, premium pricing

## Well Aligned Opportunity for

- **Refineries, oil marketing companies**- brownfield leverage
- **Biofuel producers** especially ethanol, biodiesel or advanced fuels
- Integrated energy companies

## Key Challenges

- **High production cost; 2-4x** more than conventional fuel
- Lack of domestic policy clarity and guaranteed offtake in India

## Business Model

- Partnerships with airlines
- Integration with existing refineries
- Long-term supply agreements

## Introduction and Business Case

Aviation is one of the hardest sectors to decarbonise — batteries are too heavy and offsets are not enough. Sustainable Aviation Fuel (SAF), liquid fuels quite similar to the ones currently used, and produced from feedstocks like agri-residues, used cooking oil, municipal waste and synthetic fuels (Power-to-Liquids), are perhaps the only feasible option for the aviation sector to significant decrease lifecycle $CO_2$ emissions.

For India, with air travel projected to triple by 2040, SAF is both a climate necessity and an economic opportunity: reducing import dependence, building new rural value chains and positioning India as a SAF export hub for global airlines.

While SAF still faces challenges on technology maturity and economics, strong industry and policy tailwinds, along with the significant attendant bio-economy benefits, are likely to make SAF an attractive investment domain for select Indian industries and companies.

## Market Potential for Sustainable Aviation in India

| Year | Market Size (₹ Cr) | Capacity Outlook | Drivers |
|---|---|---|---|
| 2025 | Less than 100 | Pilot/demo plants | Airline blending pilots; global pressure. |
| 2030 | 1,000-2,000 | 100-200 million litres | ICAO CORSIA compliance; oil refiners scaling SAF. |
| 2040 | 35,000-40,000 | 5-6 billion litres | Large-scale adoption; India as SAF export hub. |

## Market Segments and Applications

| Segment | Applications | Business Model | Key Drivers |
|---|---|---|---|
| Global airlines, fuel distributors | Drop-in SAF for commercial aviation | Large-scale production + long-term offtake | Airline decarbonization mandates & global SAF quotas |
| North American airlines | Jet fuel replacement | Dedicated SAF refinery + contracts | U.S. tax credits & early airline demand |
| Airlines, airports, fuel traders | Co-processed and neat SAF | Refinery integration + fuel trading | EU ReFuelEU Aviation mandate |
| Airlines, corporate | SAF supply, | Global supply & | Corporate Scope-3 |

| | | | |
|---|---|---|---|
| aviation | blending, certificates | trading platform | reduction commitments |
| Airlines, fuel blenders | HEFA & ATJ SAF | Integrated fuels + technology partnerships | Policy incentives + refinery transition |
| Airlines, ethanol producers | ATJ-based SAF | Technology licensing + project equity | Feedstock flexibility beyond waste oils |
| Airlines, corporates | Net-zero / carbon-negative SAF | Project development + long-term offtake | Premium pricing for low-CI fuels |
| Airlines, municipalities | MSW-to-SAF | Waste-to-fuel plant ownership | Landfill diversion + circular economy economics |
| Airlines, fuel marketers | HEFA & ATJ SAF | Integrated biofuels platform | Vertical integration & U.S. SAF incentives |
| Airlines, financiers | Multi-pathway SAF | Platform & aggregation model | Capital-light scale via ecosystem control |

## Typical Project Capacities & Investments Required in India

| Project Type | Typical Capacity | Indicative CapEx (₹ Cr) | Notes |
|---|---|---|---|
| HEFA/HVO → SAF (lipids: UCO, tallow, non-edible oils) | 100-400 KTPA | 1,800-6,500 | Mature route; hydroprocessing + isomerisation; renewable diesel + SAF cut. |
| Alcohol-to-Jet (ATJ; 2G ethanol/iso-butanol) | 50-200 KTPA | 1,500-4,500 | Integrates with 2G ethanol; dehydration-oligomerisation-hydro genation. |
| Fischer-Tropsch (FT; biomass/MSW/biogas + green $H_2$) | 50-150 KTPA | 2,500-8,000 | Gasification + FT; complex syngas clean-up; co-produces naphtha/diesel. |
| Co-processing in existing refineries (HEFA blend-in) | 20-80 KTPA | 250-900 | Uses available hydrotreater capacity; limited SAF %; fast-to-market. |
| e-SAF (Power-to-Liquids; $CO_2$ + green $H_2$) | 10-50 KTPA | 3,000-10,000 | Early-stage; high RE/$H_2$ intensity; premium export potential. |

## Underlying Technologies & Processes

| Element | Options | Key Traits |
|---|---|---|
| Feedstocks | Used cooking oil (UCO), agri-residues, municipal solid waste, lignocellulosic biomass, synthetic (e-fuels) | Defines sustainability, availability and cost. |
| Conversion pathways | HEFA (Hydroprocessed Esters & Fatty Acids), ATJ (Alcohol-to-Jet), FT (Fischer-Tropsch), PtL (Power-to-Liquids) | HEFA most mature; ATJ and FT scaling; PtL long-term. |
| Blending | Certified up to 50% with fossil jet fuel | Drop-in solution; requires no aircraft/engine modification. |
| Infrastructure | Integration with existing refineries, dedicated SAF biorefineries | Reduces CapEx, speeds adoption. |
| Policy drivers | ICAO CORSIA, EU mandates, Indian biofuel policy | Ensures long-term demand pull. |

## Key Challenges

| Challenge Area | Key Issues | Business Impact | India Specific | Strategic Implications |
|---|---|---|---|---|
| High Production Cost & Economic Viability | SAF significantly more expensive than conventional jet fuel; technology costs still high | Limits airline adoption without mandates or incentives; margin pressure | India lacks strong SAF blending mandates compared to EU/US | Need policy incentives, carbon pricing, and scale-driven cost reductions |
| Feedstock Availability & Supply Chain Complexity | Competition for feedstock (used cooking oil, agri-residue, waste oils, biomass) | Feedstock price volatility impacts project economics | Competing demand from bio-diesel, 2G ethanol, and CBG sectors | Diversified feedstock strategy and localized sourcing essential |
| Demand Certainty & Offtaker Agreements | Airlines sensitive to fuel price increases; voluntary adoption limited | Revenue uncertainty without long-term purchase agreements | Indian airlines operate on thin margins; cost sensitivity high | Long-term SAF purchase agreements with airlines and export buyers critical |
| Technology Maturity & Infrastructure | Multiple production pathways | Operational risk and high technical | Limited domestic commercial-scale SAF plants | Partnerships with global technology providers and |

| | | | | |
|---|---|---|---|---|
| Gaps | (HEFA, ATJ, FT) still evolving; certification requirements | complexity | currently | phased deployment |
| Policy, Geopolitics & Market Timing | Dependence on global carbon regulations and aviation decarbonization targets | Export competitiveness influenced by global sustainability standards | Opportunity to become SAF export hub but policy clarity evolving | Alignment with ICAO/CORSIA frameworks and strategic airport hubs |

## Prominent Players in the Indian Market

| Company / Entity | Focus Areas |
|---|---|
| Indian Oil Corporation (IOCL) | SAF trials with Indian airlines; feedstocks include waste oils and bio-based lipids. |
| Hindustan Petroleum (HPCL) / Bharat Petroleum (BPCL) | Building SAF capacity in upcoming bio-refineries. |
| CSIR-IIP (Indian Institute of Petroleum) | Developed indigenous SAF production technology. |
| Praj Industries | Tech provider for alcohol-to-jet (ATJ) pathways. |
| Airlines (Indigo, SpiceJet, Air India) | Early adopters of SAF blends for pilot flights. |
| Startups (GPS Renewables, BuyoFuel) | Building pathways for waste-based biofuels; exploring SAF-linked opportunities. |

## Innovation Perspectives

| Innovation | Business Opportunity | For Senior Management |
|---|---|---|
| SAF as a long-term contracted infrastructure asset | SAF infra platforms, project finance at scale | Bankable cash flows similar to midstream assets |
| Feedstock-flexible fuel pathways | Multi-pathway SAF hubs | Reduces supply risk and policy dependence |
| Ultra-low & negative-CI SAF | Carbon-negative aviation fuels | Premium pricing + carbon credit upside |
| Alcohol-to-Jet (ATJ) scaling | Repurposing ethanol assets for SAF | Breaks HEFA feedstock bottleneck |

| | | |
|---|---|---|
| Waste-to-SAF circular economy | City-linked SAF plants | Solves waste + fuel problems simultaneously |
| Power-to-Liquid (e-SAF) | Airport-adjacent e-fuel hubs | Long-term net-zero aviation solution |
| Platform & aggregation models | SAF marketplaces & certificate trading | Capital-light, high-control model |
| SAF certificates & book-and-claim | Digital SAF credit exchanges | Enables global corporate demand |
| Refinery co-processing transformation | Brownfield refinery repurposing | Low-capex, fast scaling |
| Airline-embedded SAF partnerships | Airline-anchored SAF ecosystems | Demand-locked growth |

## Concentric & Satellite Opportunities

- Feedstock aggregation and traceability networks: Concentric supply chains digitising the collection of used cooking oil, non-edible oils and agri residues with blockchain-backed traceability and assured quality.
- Refinery co-processing retrofits: Brownfield integration of SAF production within existing hydrotreater units at IOC, BPCL and HPCL refineries for low-capex, near-term deployment.
- Hydrogen and $CO_2$ integration hubs: Shared green hydrogen and captured $CO_2$ infrastructure serving ATJ, FT and e-SAF facilities under cluster-based industrial parks.
- Airport blending and storage upgrades: Infrastructure developers modernising aviation fuel hydrant systems, segregated tanks and quality labs for safe SAF handling and scalability.
- MRV and carbon credit platforms: Digital systems capturing feedstock-to-flight lifecycle data to issue CORSIA/EU-compliant carbon intensity credits and SAF certificates.
- Catalyst and process optimisation R&D: Satellite ventures innovating catalysts and process intensification for ATJ/FT pathways tailored to Indian feedstock chemistry.
- Export-oriented e-fuel projects: Coastal e-SAF facilities leveraging abundant solar and wind power for high-value export markets under long-term offtake contracts.
- Rural lipid & biomass farming cooperatives: FPO-led energy crop plantations (Pongamia, Jatropha, Sal seed) linking sustainable feedstock production with rural job creation.

## Key Takeaway for Senior Management

| Takeaway | Details |
|---|---|
| SAF is a long-term demand certainty market, not a speculative fuel play | • Airline net-zero commitments, ICAO/CORSIA frameworks, and blending mandates create structural demand<br>• ***Examples**:* airline offtake agreements, airport SAF hubs, long-term supply contracts<br>• **Competitive advantage:** early movers lock in premium customers and long-term pricing power |
| Feedstock ecosystems determine scalability and margin stability | • SAF plants compete on feedstock reliability, not just conversion efficiency<br>• ***Sub-components**:* waste oils, agri residues, municipal waste streams, alcohol-to-jet feedstocks<br>• **Competitive advantage:** proprietary feedstock ecosystems reduce volatility and protect margins |
| Technology flexibility is a hedge against pathway risk | • HEFA, ATJ, and FT pathways evolve rapidly; rigid plants risk obsolescence<br>• ***Examples**:* modular upgrading units, multi-feedstock reactors<br>• **Innovation focus:** flexible process architecture and rapid retrofit capability |
| Integrated carbon monetization amplifies project economics | • SAF value includes fuel + carbon credits + ESG premiums<br>• ***Examples**:* carbon markets, airline sustainability premiums, lifecycle emissions certification<br>• **Competitive advantage:** diversified revenue beyond fuel sales |
| Cluster deployment creates infrastructure platforms | • SAF hubs near airports and logistics centers reduce transport costs and enable scale<br>• ***Examples**:* airport fuel clusters, port-based SAF terminals<br>• **Competitive advantage:** shared infrastructure and platform logistics |

## Next Steps for Corporate Leaders

Sustainable Aviation Fuels are accelerating as airlines, airports, and corporates pursue aviation decarbonization pathways aligned with CORSIA, ICAO, and net-zero commitments. Drop-in blending capabilities, multiple technology pathways (HEFA, ATJ, FT, and emerging e-fuels), and growing policy support are expanding the market — while supply constraints, feedstock competition, and cost premiums remain primary barriers. As corporates face increasing Scope 3 travel emissions scrutiny, SAF is becoming a core lever for compliant, credible emissions reduction without fleet or infrastructure change.
This could be an attractive climate tech opportunity for industries and firms in specific sectors and industries keen on catering to this market.

**Connect with Team EAI to know more about this opportunity and take your corporate's initial steps. Send a note to consult@eai.in or talk to Muthukrishnan - 9952910083**