OHAYO GREEN ENERGY

FICCI 100
100 YEARS OF BUILDING TOMORROW

Feedstocks & Pathways to SAF

Imperatives for Commercially Viable Sustainable Aviation Fuel in India



NOVEMBER 2026

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Biomass in India | Image credits: Ohayo Green Energy ©

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FOREWORD

Indian aviation is growing at a pace few nations have seen. But growth alone is not the goal. It must also be clean, responsible and built to last. Under the leadership of Hon'ble Prime Minister Shri Narendra Modi, India is walking a path where economic growth, technology and environmental care move together. We have the opportunity to help the world fly cleaner. We also have the responsibility.

Sustainable Aviation Fuel (SAF) is at the heart of this effort. It is the most practical way to cut aviation's carbon footprint. It is also more than a fuel. It connects our farms, our renewable energy, our waste and our fuel technologies into one new value chain. What was once waste can now power flight. Our farmers can become partners in the future of aviation.

India has the feedstock. We have growing strength in renewable energy and fuel production. With the right policies, technology and industry partnerships, we can meet a significant share of our own SAF needs. We can go further and become a global supplier of sustainable aviation fuel.

The world is moving in this direction. ICAO's global framework and CORSIA have raised the urgency. India's indicative SAF blending target of 5% for international flights by 2030 gives us a clear milestone. To reach it, we must scale up domestic production, build dependable supply chains and make SAF commercially viable for investors.

I extend my best wishes for the success of the India Sustainable Aviation Fuel Summit 2026. Our aim should be to create urgency, purpose and shared responsibility among every stakeholder. Let us make sustainable aviation a defining part of India's aviation story, and let India lead the world in SAF.

(Rammohan Naidu Kinjarapu)

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Minister of State for
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Government of India

Ude Desh ka Aam Naagrik

सत्यमेव जयते

स्वच्छ भारत
एक कदम स्वच्छता की ओर



MESSAGE

India stands at the threshold of a new opportunity to transform its aviation energy landscape. As we advance towards Viksit Bharat 2047 under the leadership of the Hon'ble Prime Minister, Shri Narendra Modi, developing sustainable and indigenous energy solutions will be essential to securing our long-term aspirations. Sustainable Aviation Fuel (SAF) presents an opportunity to connect India's aviation ambitions with its strengths in agriculture, innovation and industrial development.

India's extensive agricultural resources and growing biofuel capabilities provide a strong foundation for developing a competitive SAF industry. Agricultural residues and other sustainable feedstocks can create additional value for farmers, generate new avenues for rural enterprise and support domestic fuel production. By converting these resources into viable energy solutions, India can strengthen its energy security, reduce dependence on imported fuels and establish itself as a significant supplier to the emerging global SAF market.

Realising this potential requires more than technological progress alone. It calls for coordinated action across the entire value chain, from feedstock collection and processing to fuel certification, production, distribution and adoption by airlines. The Government of India is committed to working closely with industry, fuel producers, research institutions and investors to address these challenges, encourage innovation and create an enabling environment for projects to scale up. The transition must move from ambition to implementation, and the time to build this capacity is now.

The previous India Sustainable Aviation Fuel Summit initiated an important dialogue on the opportunities and challenges associated with SAF in India. This edition will build on that foundation by encouraging practical solutions, stronger partnerships and investment-led progress. It provides an opportunity to align India's domestic capabilities with evolving international developments, including ICAO's decarbonisation initiatives and CORSIA, while advancing the country's indicative target of 5% SAF blending for international flights by 2030.

I believe that India's strengths in agriculture, entrepreneurship, technology and manufacturing can help establish a sustainable aviation fuel ecosystem that delivers benefits well beyond aviation. Through close collaboration between the Government and industry, we can create new economic opportunities, strengthen domestic capabilities and contribute to global sustainability efforts.

(Murlidhar Mohol)

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सत्यमेव जयते

भारत सरकार
नागर विमानन् मंत्रालय
GOVERNMENT OF INDIA
MINISTRY OF CIVIL AVIATION

Dated: 16th November, 2026

Message

Indian aviation is growing at a pace few nations have seen. But growth alone is not the goal. It must also be clean, responsible and built to last. Today, India is walking a path where economic growth, technology and environmental care move together. We have the opportunity to help the world fly cleaner. We also have the responsibility.

Sustainable Aviation Fuel (SAF) is at the heart of this effort. It is the most practical way to cut aviation's carbon footprint. It is also more than a fuel. It connects our farms, our renewable energy, our waste and our fuel technologies into one new value chain. What was once waste can now power flight. Our farmers can become partners in the future of aviation.

India has the feedstock. We have growing strength in renewable energy and fuel production. With the right policies, technology and industry partnerships, we can meet a significant share of our own SAF needs. We can go further and become a global supplier of sustainable aviation fuel.

The world is moving in this direction. ICAO's global framework and CORSIA have raised the urgency. India's indicative SAF blending target of 5% for international flights by 2030 gives us a clear milestone. To reach it, we must scale up domestic production, build dependable supply chains and make SAF commercially viable for investors.

The "Feedstocks and Pathways to SAF" report by FICCI and Ohayo sets a new benchmark for the sector. I complement the team for the first of its kind report on Sustainable Aviation Fuel that comprehensively addresses supply-side opportunities of the SAF ecosystem. Through meticulous work, this report brings clarity to a complex landscape.

I extend my best wishes for the success of the India Sustainable Aviation Fuel Summit 2026. Our aim should be to create urgency, purpose and shared responsibility among every stakeholder. Let us make sustainable aviation a defining part of India's aviation story and let India lead the world in SAF.

(Samir Kumar Sinha)

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MESSAGE

Indian aviation is scaling unprecedented heights. For the industry, this stellar growth carries an accompanying responsibility: It must be sustainable. Decarbonisation is no longer a distant aspiration but a business imperative. Sustainable Aviation Fuel (SAF) is the most immediate and practical lever available to reduce overall aerospace emissions.

SAF is as much an economic opportunity as an environmental one. India's agricultural base, diverse feedstock and maturing biofuel capabilities offer the building blocks for a competitive domestic SAF value chain, one that can reduce import dependence, create skilled jobs and attract long-term investment. Yet potential does not convert into production on its own. It requires producers who are confident of demand, investors who can see bankable returns, airlines that can plan their costs and manufacturers and engine makers who can assure that aircraft are ready to operate on SAF at scale. Today's aircraft are already approved for blends of up to 50 percent, and the industry is working towards flying on 100 percent SAF.

The "Feedstocks and Pathways to SAF" report by FICCI and Ohayo has tried to untie this knot. Substantial expertise, research and fieldwork has gone into producing the report. It identifies opportunities and challenges of the SAF ecosystem in India. The report delivers SAF production projections by technology readiness, and illustrative hub-and-spoke configurations.

Feedstock aggregation, conversion technologies, certification, blending, storage and into-plane infrastructure must be developed in step with demand. For this, industry looks for a stable, predictable and long-term policy framework, with early clarity on the pathway towards India's indicative target of 5% SAF blending for international flights by 2030, so that stakeholders can commit capital and capability with confidence.

SAF currently carries a significant cost premium over conventional jet fuel, and airlines operate on thin margins in a highly competitive market. Closing this gap will call for a combination of measures, including incentives for first-of-a-kind plants, innovative financing and risk-sharing structures, long-term offtake agreements and mechanisms that distribute costs fairly across the value chain. The FICCI-Ohayo report provides answers to some of those questions.

The 2nd Edition of the India Sustainable Aviation Fuel Summit builds on the dialogue begun last year and brings together airlines, aircraft and engine manufacturers, fuel producers, technology providers, financiers and policymakers around a shared purpose: moving from intent to implementation.

As the voice of Indian industry, FICCI is proud to partner with the Ministry of Civil Aviation in convening this Summit, and remains committed to working with all stakeholders to build a robust SAF ecosystem for India. I extend my best wishes for the success of the India Sustainable Aviation Fuel Summit 2026.

(Jürgen Westermeier)

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Biomass: Sugarcane and Field Residues | Image credits: Ohayo Green Energy ©

About this report

Purpose

This report presents an edition of a 2026 research assessment of India's Sustainable Aviation Fuel (SAF) feedstock base, conducted and prepared by Ohayo Green Energy and published in association with the Federation of Indian Chambers of Commerce and Industry (FICCI) for the wider Indian SAF ecosystem.

It sets out which feedstocks matter on which horizon, how much of each can realistically be mobilised, what holds each back, and where organisations entering the supply chain can act. Its distinctive contribution is regional granularity: fieldwork across collection clusters, residue belts, rendering hubs and plantation regions, combined with a transparent method for separating resource estimates from deliverable supply.

Scope of this edition

The report covers feedstock mapping and ranking, the methodological framework, carbon-intensity and accessibility filters, feedstock-specific supply-side avenues, SAF production projections by technology readiness, and illustrative hub-and-spoke configurations. It is not an investment recommendation, a project appraisal or a policy roadmap.

Prepared by
Ohayo Green Energy

In association with
Federation of Indian Chambers of Commerce and Industry (FICCI)

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How to read the numbers

Figures are drawn from public datasets (including the Biomass Atlas, Petroleum Planning and Analysis Cell (PPAC), Ministry of New and Renewable Energy (MNRE), Indian Council of Agricultural Research (ICAR), Bureau of Energy Efficiency (BEE) and Airports Authority of India (AAI), company disclosures and Ohayo Green Energy primary research, unless marked as an estimate or modelled scenario. Generation, surplus, collectible and mobilisable volumes describe different stages of availability and are labelled as such. Unless stated otherwise, t denotes metric tonnes and MMT million metric tonnes.

Primary research

Field insights are derived from interviews with 80–90 stakeholders across the biomass, waste-lipid and fuel supply chains conducted by Ohayo Green Energy in 2026.

Disclaimer

This report has been prepared for information purposes. Project capacities and statuses reflect the position at the time of assessment (August 2026) and are as announced by the companies concerned. Nothing in this report should be read as a statement that any feedstock, pathway or volume is certified as eligible under the Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA).



Image: Airbus

India's SAF Feedstock Landscape · Ohayo Green Energy Private Limited © All rights reserved.

Preface

Ohayo Green Energy Private Limited

India imports hundreds of millions of tonnes of fossil carbon to fuel its economy annually in large bulk cargoes. At the same time, users across the nation discard even larger quantities of carbon atoms embedded in various solid, liquid and gaseous waste streams across its fields, kitchens, municipal dumpsites, effluent discharges and industrial emissions. Leveraging this paradox for value creation is what brought Ohayo Green Energy to this study.

When we set out to assess India's potential for Sustainable Aviation Fuel (SAF), we discovered quite soon that feedstock abundance on paper rarely reflects what can be delivered to a refinery gate. The real challenge was not counting theoretical carbon atoms, but understanding the human, logistical, and commercial friction between available resource and delivered reality.

Stepping out of the ivory tower of spreadsheets into the ground realities of the field proved humbling. We met street vendors who poured used cooking oil away because they lacked access to compliant collection, and farm aggregators in Punjab racing against brief harvest windows and tough regulations with little more than informal credit to sustain their economic imperatives. We spoke with refiners, technologists, and policymakers who see the immense promise of domestic bio-refining, but remain boxed in by uncoordinated supply chains and uncertain demand signals complicated by periodic policy tweaks, ethanol – which has a value chain overlap with SAF – being a classic case in point.

Our biggest learning has been that India's SAF journey will not be won or lost in the conversion reactor. Technology is ready, but logistics, fair pricing of usable carbon resources on a level playing field, trustworthy traceability and policy consistency are what will turn dispersed bio-resources into CORSIA-compliant jet fuel.

This report is our attempt to reflect that ground reality with clarity and candour. We hope it offers a practical foundation for industry and government to build the collection, storage, and financing partnerships needed to take Indian SAF from aspiration to flight.

> *"Stepping into the ground realities of the field was humbling. Analysing feedstock data versus assessing its availability in rural India, show vastly different pictures."*
>
> From the Preface



On paper
Feedstock looks abundant

In the field
Far less reaches a refinery gate



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Renewable Energies Advisor

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Image: Airbus

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Executive summary

India has the carbon resources, technology and finance to build a robust Sustainable Aviation Fuel (SAF) ecosystem. What it lacks is organised, traceable access to its own feedstock.

India consumed about 9 MMT of Aviation Turbine Fuel (ATF) in Financial Year (FY) 2024–25, and demand is projected to reach 12.1–13.8 MMT by 2030. Meeting even modest SAF blending levels from domestic resources will depend less on the size of India's carbon base, which is large, than on how much of it can be collected, documented and delivered to a plant at the required input quality.

Substantial resources, an immature supply chain. The study maps more than 460 MMT a year of domestic recyclable or renewable carbon, against about 330 MMT of carbon that India imports each year in crude oil, coal and gas. Most of this domestic carbon sits in dispersed, seasonal or informal streams with no collection chain **suitably** built for aviation fuel.

Waste lipids carry the first volumes. Used Cooking Oil (UCO) and animal tallow can support Hydroprocessed Esters and Fatty Acids (HEFA), the only pathway at commercial readiness in India today. India generates about 8 MMT of UCO a year, but only about 3 MMT is considered collectible and under 30% of that is formally collected. It is assessed that most of the collectible oil re-enters the food chain through informal traders. UCO is, hence, an access and traceability problem, not a resource problem.

Agricultural residues are the structural backbone. India generates approximately 750 MMT of biomass a year, with an estimated 200–300 MMT surplus, and five states account for 47.7% of generation and about 65% of the surplus. Fieldwork in Punjab and Haryana shows that the residue chain fails before the SAF refinery: straw must be baled within about 20 days of harvest, aggregators borrow at high interest rates of ~30% to fund inventory, and 15–25% of bales are lost in open storage. These gaps are fixable: covered depots costing ₹250–400 a tonne can recover storage losses in their first season.

Diversifiers for the 2030s. Tree-borne oils, short-gestation oilseeds and ~15 million hectares of marginal, fallow or under-utilised land could widen the lipid or purpose-grown lignocellulosic biomass base, but none of these yet have organised ecosystems. Municipal Solid Waste (MSW) and industrial carbon dioxide (CO_2) are longer-term options, gated by waste segregation, low-carbon hydrogen and firm renewable power.

FIGURE 1 **A portfolio that evolves by readiness, not by resource size**

NEAR TERM to 2030	MEDIUM TERM 2030–2040	LONG TERM 2040 and beyond
Waste lipids	**Agricultural residues**	**MSW and industrial carbon**
UCO, tallow, tree-borne oils where supply is evidenced	Paddy and wheat straw, cane trash, bagasse; energy crops	Organic MSW; point-source CO_2 from power, steel, cement
Base ~3 MMT/yr collectible UCO	**Base** 200–300 MMT/yr surplus biomass	**Base** 1,949 MMT CO_2e in PAT scope
Regions Metro clusters: Delhi, Mumbai, Bengaluru, Chennai	**Regions** Punjab, Haryana, UP, Maharashtra, MP, Rajasthan	**Regions** Odisha, Chhattisgarh, Gujarat, MP corridors
Pathway HEFA and Lipid Co-processing	**Pathway** Alcohol-to-Jet and Fischer–Tropsch	**Pathway** Gasification, PtL, Gas fermentation
Key Challenges Collectible, traceable, eligible supply	**Key Challenges** Capturing biomass surplus for SAF, storage, working capital	**Key Challenges** Segregation, CO_2 capture, Green hydrogen meeting LCA and economic targets
Readiness **TRL 8–9**	**Readiness** **TRL 6–8**	**Readiness** **TRL 4–6**

Abbreviations: TRL, Technology Readiness Level; PAT, Perform, Achieve and Trade scheme; CO_2e, Carbon Dioxide Equivalent; PtL, Power-to-Liquid; LCA, Lifecycle Assessment; UP, Uttar Pradesh; MP, Madhya Pradesh.

India's SAF Feedstock Landscape · Ohayo Green Energy Private Limited © All rights reserved.

Executive summary

Production will follow feedstock readiness. Announced SAF capacity stands at about 0.50 MMT a year, 82% of it HEFA, and almost all of it is still pre-commissioning. In the study's base scenario, SAF demand rises from 0.16 MMT in 2030 to 1.1 MMT in 2035 and 3.4 MMT in 2045, the equivalent of 14–20 commercial-scale biorefineries. Near-term output rests on HEFA and refinery co-processing; Alcohol-to-Jet (AtJ) and Fischer–Tropsch (FT) can scale on lignocellulosic residues and MSW through the 2030s; Power-to-Liquid (PtL) and gas fermentation remain prospective.

Logistics decides viability. Dispersed, low-density feedstock only becomes bankable through a hub-and-spoke architecture: baling, densification and pre-treatment at spokes within about 25 km of source, covered custody depots, and centralised conversion near refineries, airports and ports. Haryana State Government's crop residue management programme, scaled from six hotspots to 600+ villages, shows that source-level mobilisation can work in India.

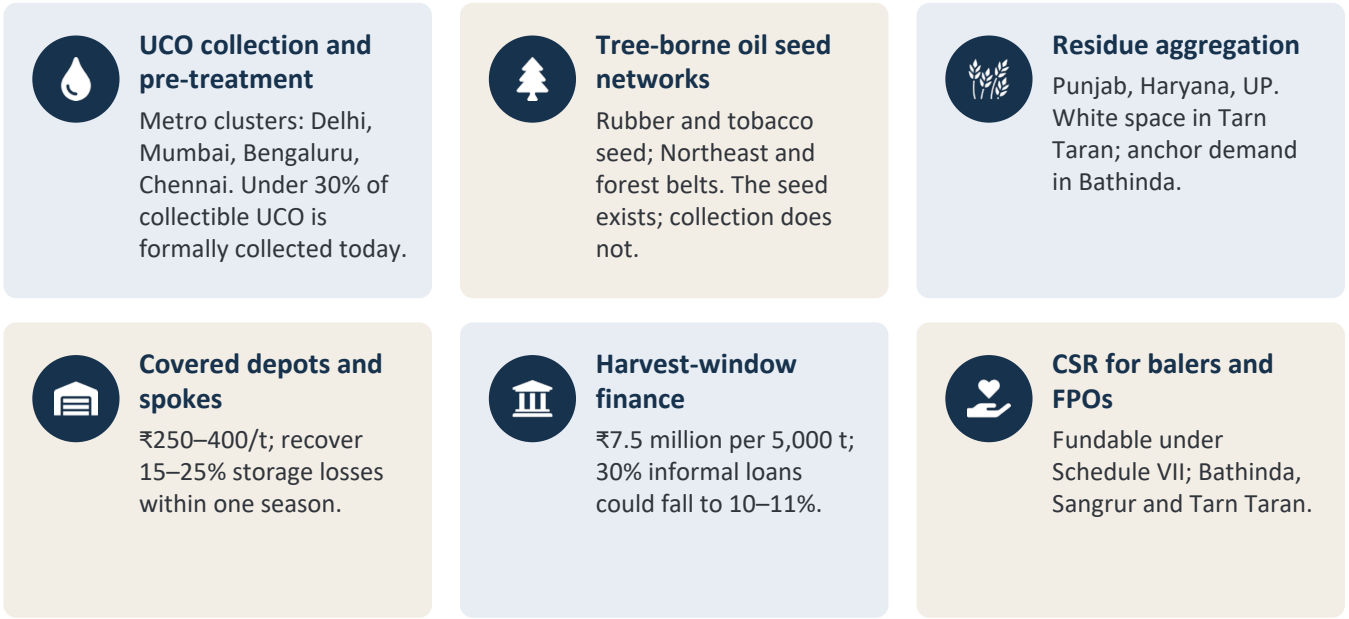
Carbon intensity is decided by inputs, not labels. HEFA-UCO clears both the CORSIA threshold and the stricter European Union (EU) limit, but hydrogen accounts for 64.6% of its modelled footprint. Green hydrogen meeting India's 2.0 kilograms of CO_2e per kilogram ($kgCO_2e/kg$) standard cuts HEFA-SAF to 5.85–9.30 grams of CO_2e per megajoule (gCO_2e/MJ); drawing just 5% of electrolyser power from the grid breaches that standard.

Granular and transparent by design. The study combines regional feedstock mapping with fieldwork across 80–90 stakeholders in collection clusters, residue belts, rendering hubs and plantation regions. Every figure is labelled by stage of availability (generation, surplus, collectible or mobilisable), and carbon intensity is assessed with the Greenhouse gases, Regulated Emissions, and Energy use in Technologies (GREET) model and International Organization for Standardization (ISO)-based lifecycle methods against CORSIA thresholds, localised for Indian grid, hydrogen and logistics conditions.

Where the ecosystem can act now. The study's supply-side findings point to concrete **opportunities**: formal UCO collection and pre-treatment in the metro clusters; seed-collection networks for rubber, tobacco and other tree-borne oils; residue aggregation in under-served districts such as Tarn Taran, Punjab, India; covered depots; harvest-window working capital; and Corporate Social Responsibility (CSR) funding for balers and Farmer Producer Organisation (FPO) capability, which the study found can be supported under Schedule VII of the Companies Act. The ecosystem playbook that follows sets these out by participant.

CORSIA as the baseline. Whatever financial and policy mechanisms national authorities adopt, CORSIA's sustainability criteria and lifecycle methodology should remain the reference for what counts as SAF feedstock.

FIGURE 2 **Six supply-side openings identified by the study**



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SAF feedstock: Ground Reality in India

~8 MMT

of UCO generated a year; about 3 MMT collectible, and under 30% of that formally collected

~60%

of collectible UCO estimated to re-enter the food chain through informal traders

200–300 MMT

of surplus biomass a year, out of about 750 MMT generated

47.7%

of gross biomass from five states (UP, MP, Rajasthan, Punjab, Maharashtra); ~65% of surplus is in five states

15–25%

of straw bales lost in uncovered storage; covered depots cost ₹250–400 a tonne

15 Mha

(Mha = million hectares) of marginal or fallow land: an indicative base for non-food oilseeds

1,949 MMT

CO_2e of industrial emissions in PAT scope; the largest operating capture unit takes 60,000 t a year

~0.50 MMT

a year of announced SAF capacity, 82% HEFA, almost all pre-commissioning

3.4 MMT

of SAF demand in 2045 in the base scenario: 14–20 commercial-scale biorefineries

64.6%

of HEFA-UCO's modelled carbon footprint comes from hydrogen production

Sources: Ohayo Green Energy feedstock assessment and demand model (2026), drawing on Food Safety and Standards Authority of India (FSSAI), Biomass Atlas, BEE PAT, World Economic Forum (WEF) and company disclosures; Yang and Yao harmonised HEFA inventory.



Image: Airbus

Ecosystem playbook: supply side

The study's primary and secondary research points to specific openings for organisations entering or scaling in India's SAF feedstock chain. These are evidence-based signals, not investment recommendations.

COLLECTORS AND AGGREGATORS

Collect and pre-treat used cooking oil

- **Where:** about 80% of collectible UCO sits in three clusters (north, west and south) centred on Delhi, Mumbai, Bengaluru and Chennai.
- **The gap:** formal collection covers under 30% of the ~3 MMT collectible pool. Compliant collectors pay ₹60–70 a litre; informal traders pay ₹25–30 and resell into food.
- **Certification pays:** the leading certified exporter averaged US$2,455/t (Feb 2024) against a US$1,290/t average.
- **What works:** Repurpose Used Cooking Oil (RUCO)-registered collection, filtration and de-metallisation at spokes, and digital chain of custody to the refinery gate. High-acid Indian UCO makes pre-treatment a business in itself.
- **Reach:** two-tier haulage adds only 1.13–8.19 gCO_2e/MJ, so catchments can be national.

AGRI-ENTERPRISES, PLANTATIONS, FPOS

Grow and collect tree-borne oils

- **Rubber seed:** Kerala and Karnataka plantation belts; kernels 40–50% oil; ~30,000 t of oil a year indicative, with no organised collection yet.
- **Tobacco seed:** a by-product of 0.45 Mha under cultivation; 38% oil; ~188,000 t a year indicative.
- **Northeast and forest belts:** Nahor in Assam and Arunachal Pradesh (40–60% oil); mahua, sal and kusum through tribal forest-produce federations.
- **Marginal land:** Marginal land opportunities for HEFA oilseeds in Rajasthan, Madhya Pradesh and Chhattisgarh; Moringa (2–4 years to mature; 65–80% oleic oil) is a medium-to-long-term option for planting programmes in the southern belts, Chhattisgarh, Jharkhand, Bundelkhand where rural employment can be stimulated through this.
- **Transitional Opportunity:** Invasive Chinese tallow, abundant in Himachal Pradesh, offers scope to harvest existing plants for several years.

BIOMASS AGGREGATORS AND FPOS

Aggregate crop residues where the gaps[1] are

- **White space:** Tarn Taran was Punjab's highest-burning district in 2025 (Punjab Pollution Control Board (PPCB)) and has few formal aggregators.
- **Anchor demand:** A second-generation (2G) ethanol plant in Bathinda needs ~200,000 t of straw a year from within ~50 km. Sangrur already has proven offtake.
- **Competition:** Ludhiana boilers pay ₹1,200–1,800/t for straw; wheat straw fetches ~₹9,500/t as fodder.
- **Route by moisture:** dry paddy straw needs 1.7–2.9 t per tonne of SAF against 15 t per tonne of biogas.
- **Source through FPOs:** holdings are under 2 ha and over 90% of harvesting is informal.

[1] Here gaps identified in Punjab, India are highlighted. Similar gaps and opportunities are present across various states.

LOGISTICS AND PRE-PROCESSING INVESTORS

Build spokes and covered depots

- **Spokes** within ~25 km of source for baling, pelletisation and UCO filtration; conversion hubs near refineries, airports and ports.
- **Covered, fire-safe depots** cost ₹250–400/t and recover open-storage losses (15–25%, or ₹90–130 million a season on a 300,000 t baseline) in the first season.
- **Depots double as custody nodes,** logging farm-level origin for CORSIA audit.
- **Value sits in preparation:** pellets realise ₹7,000/t against ₹1,025/t paid to the farmer.
- **Co-products** (renewable diesel, naphtha and liquefied petroleum gas, LPG) can lift first-of-a-kind plant Internal Rate of Return (IRR) by 15–20%.

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Ecosystem playbook: enablers

Beyond new entrants, the evidence points to roles for large corporates, lenders, fuel producers and public agencies, several of which can move without new legislation.

LARGE CORPORATES

Put CSR to work on crop residue

- **Eligible under CSR law:** Balers and residue equipment for FPOs, village-level aggregation centres, bioenergy skilling and climate-smart agriculture training can be funded under Schedule VII of the Companies Act.
- **Highest impact:** Bathinda, Sangrur and Tarn Taran in Punjab, where residue offtake demonstrably cuts field fires.
- **Investment Opportunities:** Covered storage depots; planting material for pongamia, jatropha and other non-food oilseeds in Chhattisgarh, Jharkhand, Bundelkhand and the southern belts.
- **Necessary, not sufficient:** CSR equipment mobilises supply but not SAF demand. Link CSR deployment to committed residue buyers.
- **Food-service outlets must mandatorily** route UCO only to RUCO-registered collectors.

BANKS, NBFCS AND INVESTORS

Finance the harvest window

- **Working capital:** aggregating 5,000 Metric Tonnes (MT) of rice straw in a 20-day window needs about ₹7.5 million up front, roughly three months before refinery payment.
- **Cost of money:** informal lenders charge ~30%; invoice discounting against Public Sector Undertaking (PSU) purchase orders can cut this to 10–11%. Priority-sector lending treatment would widen access.
- **Finance storage, not just straw:** covered depots cost ₹250–400 a tonne and recover the 15–25% of bales lost in open storage, so stored stock is protected collateral and wastage is reduced.
- **Write harvest-cycle loan terms:** short-tenor seasonal facilities, drawn in the 20-day window and repaid from refinery payment about three months later, secured on purchase orders and stored stock.

REFINERS AND SAF PRODUCERS

Secure inputs, not just capacity

- **Contract the field:** named, written purchase agreements formalise aggregators; over 90% of harvesting is uncontracted, so chain of custody never starts.
- **Decarbonise hydrogen (H2) first: H_2 contributes to ~65%** of HEFA-UCO's modelled footprint. Firm round-the-clock green power at 75–85% load factor **can keep** hydrogen Greenhouse Gas (GHG) emissions within India's 2.0 $kgCO_2e/kg$ standard for Green H_2.
- **Treat tallow as supplementary:** its price tracks UCO (r = 0.45) and exports are inelastic; source from organised rendering in Muzaffarnagar, Hyderabad and Kolkata.
- **Engage Carbon Capture and Utilisation (CCU) sites early:** operating capture is tens of thousands of tonnes, none of it yet going to fuel.

STATE AGENCIES, FPOS AND MUNICIPALITIES

Capture value at source

- **Price signal:** Punjab farmers keep barely ₹1,025 of a ₹7,000/t chain, and 69% gave straw away free in 2024, so burning stays the rational choice.
- **Replicable model:** Haryana's crop residue programme (69% fewer fires in its pilot, 666 villages, 150,000+ farmers sharing balers through an app) is a template for **other states like** UP and MP.
- **Store off the field:** bales piled on leased farmland cut the next crop's yield by 30–40% in Haryana.
- **Municipal bodies: Effective** segregation, not collection, is what unlocks MSW for fuel.

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1 Feedstock portfolio prioritisation and strategic rationale

The question is not how much feedstock India generates, but how much suitable material can be secured and supplied reliably for SAF.

India's ability to build a sustainable aviation fuel industry rests on a broad range of carbon resources, from waste oils and agricultural residues to energy crops, Municipal Solid Waste (MSW) and industrial carbon. They are not equivalent opportunities. Resources are dispersed, collection is often informal, and potential feedstocks already serve established food, agricultural, fuel, power and industrial markets.

A portfolio that evolves in phases. In the near term, waste lipids (used cooking oil and animal tallow) offer the most immediate route through the established HEFA pathway, limited by what can be collected into compliant supply chains. This includes an opportunity for increased production and cultivation of Tree-borne oils (TBOs) and Short-Gestation Oil Seeds (SGOCs).

In the medium term, agricultural residues offer a far larger base for Alcohol-to-Jet (AtJ) and Fischer–Tropsch (FT) as collection systems develop. In the longer term, energy crops, increased cultivation of tree-borne oils, industrial carbon and MSW could diversify supply, subject to technology, infrastructure, energy inputs and proven lifecycle performance.

The sequence reflects readiness, not resource size. The horizons are a prioritisation framework, not a guarantee that any feedstock will be commercially available by a given year. This chapter sets out the portfolio, the rationale behind it, and why a hub-and-spoke logistics model is a precondition for every feedstock beyond waste lipids.



Image: Airbus

1.1 Why domestic feedstock matters: India's carbon balance

India imports about 330 MMT of carbon a year in fossil fuels, while more than 460 MMT of recyclable or renewable carbon is generated at home.

SAF is an energy-security question for India before it is a decarbonisation one. In 2022 India imported 212 MMT of crude oil, 180 MMT of coal including pet coke and 20 MMT of natural gas, equivalent to roughly 330 MMT of carbon a year. Every tonne of carbon recovered from domestic waste and residue streams reduces that import requirement as well as aviation emissions.

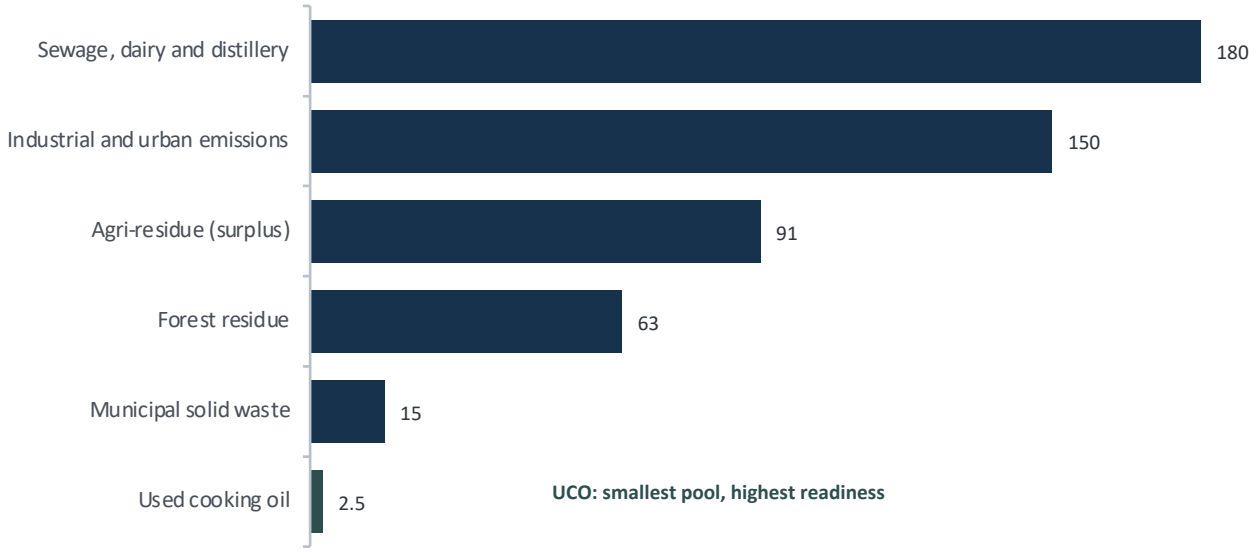
The study's carbon mapping shows a large domestic base. Sewage, dairy and distillery streams hold about 180 MMT of carbon a year, industrial and urban emissions about 150 MMT, surplus agricultural residue about 91 MMT and forest residue about 63 MMT. MSW contains about 15 MMT, and UCO about 2.5 MMT.

Priority follows readiness, not size. The largest pools are not the nearest. Sewage, dairy and distillery streams are largely committed to biogas and ethanol, and industrial carbon needs capture, hydrogen and firm clean power before it can become fuel. UCO, the smallest pool, ranks first on readiness because it feeds HEFA, the only commercially proven SAF pathway available in India today.

India currently exports SAF precursors. Waste lipids and biomass briquettes are shipped to markets that convert them into green fuel, while India imports fossil carbon. Exporting precursors transfers refining margins and green jobs abroad, and prevents India from counting the lifecycle emission reductions towards its own blending goals.

SAF competes for the same molecules. Ethanol and compressed biogas (CBG) carry the most mature commercial push in India, so SAF competes with fuel, chemical and power markets for the same feedstocks. Pathway choice and early offtake positioning matter.

FIGURE 3 Potential carbon in India's domestic sources (MT of carbon per year)



Source: Ohayo Green Energy carbon mapping (2026), drawing on Biomass Atlas, MNRE, ICAR, PPAC and BEE data. Potential carbon content, not mobilisable feedstock.

WHAT THIS MEANS FOR THE ECOSYSTEM

The scarce capability in India's SAF chain is not carbon or conversion technology but the ability to turn dispersed carbon into documented, delivered feedstock. Collectors, aggregators and pre-processors sit at the binding constraint.

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1.2 Feedstock portfolio prioritisation at a glance

Four horizons, each with a distinct role in the portfolio and a distinct test that decides whether it delivers.

FIGURE 4 **Target feedstocks by horizon, domestic base, regional belts and pathway**

HORIZON	ROLE AND TARGET FEEDSTOCKS	DOMESTIC BASE	REGIONAL BELTS	PATHWAY (TRL)
NEAR TERM to 2030	**Early production for 1–5% blending** UCO, animal tallow, palm residues (stearin, PFAD)*, tree-borne oils (pongamia, jatropha, mahua, sal)	**~3 MMT/yr** collectible UCO; **~30,000 t/yr** rubber seed oil	Metro clusters: Delhi, Mumbai, Bengaluru, Chennai	HEFA, co-processing TRL 8–9
MEDIUM TERM 2030–40	**Structural volume backbone** Paddy straw, wheat straw, sugarcane trash, bagasse	**200–300 MMT/yr** surplus biomass	Punjab, Haryana, UP, Maharashtra, MP, Rajasthan	AtJ, FT TRL 6–8
MEDIUM TO LONG TERM 2030+	**Food-neutral hedge against UCO** Short-gestation oilseeds (niger, carinata, camelina), moringa, sapium, calophyllum, tobacco and rubber seed oil, fish oil	**~15 Mha** marginal or fallow land	Rajasthan, UP, MP, Chhattisgarh	HEFA (crops at early stage)
LONG TERM 2040+	**Decouples SAF from land and seasonality** Industrial point-source CO_2 (flue gas), organic MSW	**1,949 MMT CO_2e** (PAT scope); **~15 MMT/yr** carbon in MSW	Odisha, Chhattisgarh, Gujarat, MP industrial corridors	Electro-SAF / e-SAF, gasification TRL 4–6

*Source: Ohayo Green Energy feedstock portfolio prioritisation (2026). *Palm stearin and PFAD are supplementary comparison materials, subject to verified origin and CORSIA eligibility.*

Three principles behind the ranking

Keep definitions distinct. Gross generation, theoretical potential, surplus, collectible and mobilisable volumes, like tonnes of feedstock, carbon and CO_2e, measure different things. The domestic-base column mixes these deliberately and labels each.

Assess readiness and sustainability together. A large resource may be costly to collect; a mature pathway may lack material; a feasible route may miss lifecycle targets. CORSIA is the reference framework throughout.

Let regional conditions decide. Crops, competing uses, seasonality, collection, storage and transport determine what can be supplied within a defined catchment. National totals set context; they do not identify supply.

Horizons are not commissioning dates. The sequence indicates broad readiness. Each feedstock still has to clear its own test: collectible and traceable supply for lipids, genuine surplus for residues, agronomy and land safeguards for crops, and energy inputs for CO_2 and MSW.

Matched to blending ambition. India's indicative SAF blending targets for international flights (1% in 2027, 2% in 2028 and 5% in 2030) can be met from the near-term row if collection and traceability improve. Blending beyond that, and any extension to domestic flying, depends on the medium-term row being built in parallel.

READING THE TABLE AS AN ENTRANT

Each row names its regional belts. Those are where collection, aggregation and pre-processing capacity will be needed first, and where early movers can secure supply relationships before conversion capacity arrives.

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1.3 Strategic rationale for each horizon

Each horizon plays a different role, and each is limited by a different constraint.

Near term: waste lipids buy time

HEFA is the only fully commercialised pathway available in India and the lowest-capex route, at about US$1,850 per tonne of annual capacity. About 80% of India's collectible UCO sits in three clusters, which keeps collection costs down and allows low-cost aggregation. But collectible volume is limited and contested by food, biodiesel and export markets, so waste lipids are a vital bridge for the first blending targets rather than a long-term base. Tallow and palm-derived materials supplement, but do not substitute for, UCO.

Medium term: residues carry the volume

With 200–300 MMT a year of surplus biomass, residues are the only pool large enough to carry blending beyond the waste-lipid ceiling, and they create localised rural supply chains. Their contribution depends on surplus after fodder, soil, boiler and power uses, short harvest windows, storage losses and transport cost. Capital intensity is higher, at about US$3,500–9,000 per tonne of annual capacity for AtJ, but becomes more competitive as premium UCO supplies tighten.

Medium to long term: crops hedge the lipid market

Non-food oilseeds grown on about 15 Mha of marginal land could hedge volatile UCO export markets without displacing food crops. Viability depends on agro-climate, yields, water, planting material and a route to market, and crop oils are not sustainable or eligible by category alone.

Long term: industrial carbon and MSW decouple supply

Unlike UCO or crop residues, industrial CO_2 and MSW decouple SAF from land, weather and food-versus-fuel risk. India's MSW holds about 15 MMT of carbon a year and would ease landfill pressure, while 1,949 MMT CO_2e of PAT-registered emissions offer concentrated, stable carbon. Both depend on capture or preparation, low-carbon hydrogen and power, and demonstrated lifecycle performance.

FIGURE 5 What each horizon offers, and what limits it



OPPORTUNITY BY HORIZON

For new entrants, the near-term horizon rewards collection and traceability capability; the medium-term horizon rewards aggregation, storage and harvest-window finance; and the medium-to-long horizon rewards agronomic trials and seed networks started now, ahead of demand.

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1.4 Hub-and-spoke analysis: why central plants cannot go it alone

The economics of residue-based SAF are decided upstream of the refinery, in aggregation and densification, not in the conversion step.

FIGURE 6 **Four fieldwork findings on moving fragmented feedstock to a refinery**

01 The resource is fragmented
Feedstock is spread across sub-2-hectare holdings and seasons; no single plant can be fed economically from its own catchment.

02 Raw biomass does not travel
Untreated residues and unfiltered waste oil carry too little energy per tonne to justify the freight they attract.

03 Densification changes the ratio
Bales, pellets, pyrolysis oils and filtered, de-metallised UCO move at far better energy density. Value is created upstream.

04 Hubs work only as converters
Large plants should run the capital-intensive conversion, taking pre-processed intermediates from many spokes.

Source: Ohayo Green Energy primary research, 2026.

Fieldwork tested whether India's dispersed feedstock could be fed directly to large central plants. It cannot. Agricultural residues have low bulk density, arrive in seasonal cycles and are generated across thousands of small farms; UCO comes from restaurants, hotels, institutional kitchens and food processors; tallow follows organised rendering. India also lacks the collection systems, pre-processing hubs and logistics networks needed for reliable, large-scale supply to fuel specifications set by ASTM International (formerly the American Society for Testing and Materials).

Competing uses narrow the base. Residues already serve power generation, ethanol, fodder and soil health, so the gross quantity generated cannot be treated as what a SAF plant can use. Planning has to start from the surplus left after existing uses and collection constraints.

The answer is a three-tier architecture. Collection and pre-processing spokes sit within about 25 km of source, baling and pelletising residues and filtering waste oil. Covered storage and custody depots protect seasonal stock and record chain of custody.

Centralised conversion hubs, co-located with refineries near airports and ports, run the complex drop-in conversion and capture co-products such as renewable diesel, naphtha and LPG.

The chain, not the plant, is what fails. A large conversion plant cannot make up for a weak upstream supply chain: one refinery's 2G plant has run at about 62% of capacity because feedstock intake is constrained. Chapter 5 applies the model regionally.

Carbon and cost both favour spokes. Local pre-processing raises energy density and cuts per-unit hauling cost, and it removes the moisture that makes raw residue expensive to move. Because decentralised pre-treatment keeps freight emissions low, a hub can draw on a national catchment without a carbon-intensity penalty on the finished fuel. Spokes are also where farm-level and kitchen-level origin can be recorded, which is the starting point for any CORSIA chain of custody.

OPPORTUNITY

Spoke-level businesses (baling services, pellet units, UCO filtration and de-metallisation) need a fraction of the capital of a SAF plant, and sit exactly where the scarcity is.

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2 Methodological framework and data transparency

What is reported as available can differ substantially from what can be collected, processed and supplied reliably to a SAF plant.

India's SAF feedstock opportunity cannot be established through national resource estimates alone. Feedstocks are unevenly distributed, generated at different times of the year and already serve established markets.

The assessment therefore brings together five connected dimensions: feedstock availability and regional distribution; existing uses and supply-chain constraints; conversion technology and project readiness; sustainability and lifecycle emissions; and the policy and market conditions that influence deployment.

Our four methods of conducting research serve different purposes. Published datasets set the quantitative starting point; field inputs show how resources are collected and traded in practice; technology and lifecycle assessments test the suitability of pathways; and modelling explores supply and demand under different assumptions.

The objective of our study is not to identify a single headline estimate of India's SAF potential. It is to separate the resources that exist from the volumes that could realistically be mobilised, to apply carbon-intensity, sustainability and accessibility filters consistently, and to identify the conditions that decide the difference.

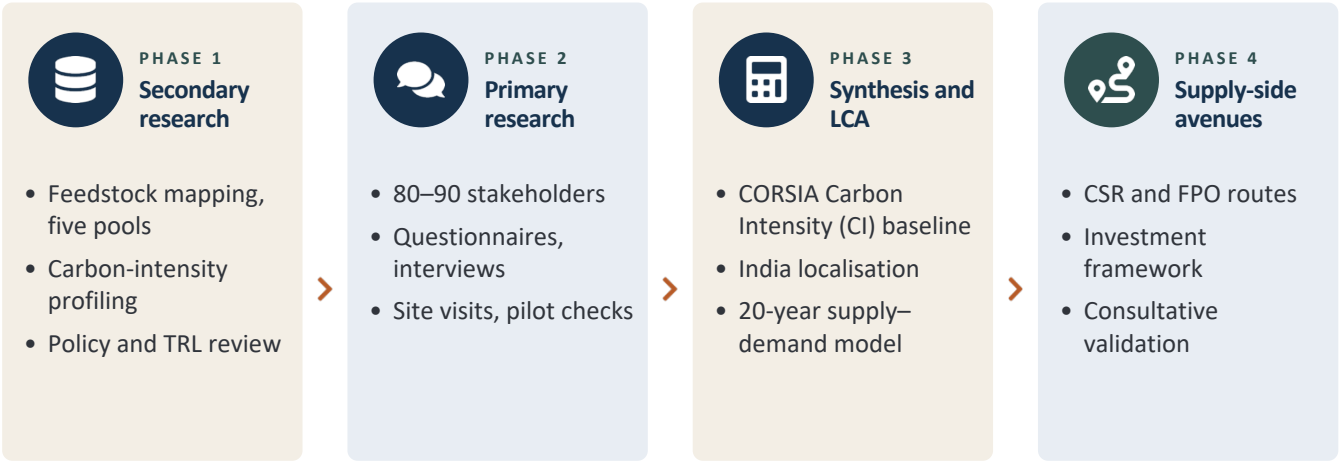


Image: Airbus

2.1 Building the evidence base in four phases

Public evidence on Indian SAF is plentiful but fragmented. The work was joining feedstock, policy and technology data into one comparable picture, then testing it in the field.

FIGURE 7 **The four-phase assessment approach**



Secondary research. Feedstock mapping compiled annual availability and logistics for five resource groups (waste lipids, carbohydrate-based feedstocks, lignocellulosic biomass, mixed waste streams and carbon-containing industrial streams) plus unrealised potential on fallow land. Reference sources include the Biomass Atlas, MNRE, ICAR, PPAC, Ministry of Petroleum and Natural Gas (MoPNG), Directorate General of Civil Aviation (DGCA) and International Civil Aviation Organization (ICAO). Each source does a different job: datasets estimate generation and distribution, policy documents set the context, technical literature informs readiness and project disclosures show the status of proposed capacity.

Policy benchmarking. The National Policy on Biofuels, DGCA circulars, state schemes and CORSIA criteria were reviewed, then compared with ReFuelEU Aviation (the EU's SAF mandate) and the UK SAF mandate to understand different approaches, not to assume they transfer directly to India.

Technology readiness. Technology readiness levels, yields and chokepoints were assigned across HEFA, AtJ, FT synthetic paraffinic kerosene, catalytic hydrothermolysis jet, e-SAF and co-processing, drawing on International Energy Agency (IEA) Bioenergy Task 39, ASTM D7566 and the International Air Transport Association (IATA) SAF Registry, alongside bibliometric mapping of research at Indian Institutes of Technology (IITs) and Council of Scientific and Industrial Research (CSIR) laboratories.

Primary research and synthesis. Fieldwork validated feedstock data and surfaced bottlenecks (next page). Lifecycle benchmarks were then localised for Indian conditions, a 20-year model projected SAF supply against ATF demand to 2045 with sensitivity analysis, and a structured assessment of strengths and weaknesses tested domestic readiness on infrastructure, feedstock diversity and regulatory maturity.

Impact beyond fuel. The assessment also tested what SAF-directed carbon could deliver beyond fuel substitution: emissions avoided by routing the right feedstock to the right pathway; domestic investment, import substitution and better use of refinery assets; and rural stimulus through farmer income, stronger FPOs, collection infrastructure and local enterprise. These map to Sustainable Development Goals 7, 8, 9, 12, 13 and 17. Impact depends on where the carbon is sourced, how it is processed and what competing use it displaces.

Supply-side avenues. The final phase translated findings into supply-side avenues, including routes for corporate CSR capital (village-level aggregation centres, bioenergy skilling, climate-smart agriculture), the treatment of collection businesses, FPOs and plants as distinct investment classes, and validation with stakeholders.

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2.2 Field validation: where the assessment looked

Field engagement surfaces constraints that are invisible in national or state statistics. The cluster maps and price points in this report come from operators, not desk estimates.

Published datasets cannot capture every condition that affects how feedstocks are collected, traded, stored and used. The assessment engaged about 80–90 stakeholders across government bodies, public-sector refiners, airlines, technology providers, academia and Non-Governmental Organisations (NGOs), through semi-quantitative questionnaires tailored to each group, telephonic and in-person interviews, and site visits. Progress on SAF pilot projects was documented directly rather than taken from announcements.

Where. Mapping and fieldwork covered urban and tourism-centre sources for UCO and mixed waste; Muzaffarnagar, Delhi, Hyderabad, Chennai and Kolkata for tallow; Punjab, Haryana and Uttar Pradesh for paddy and wheat straw; and Uttar Pradesh, Maharashtra, Karnataka and Tamil Nadu for bagasse. Southern plantation belts were assessed for rubber seed, the Northeast for Nahor, and Odisha, Chhattisgarh, Gujarat and Madhya Pradesh for industrial carbon.

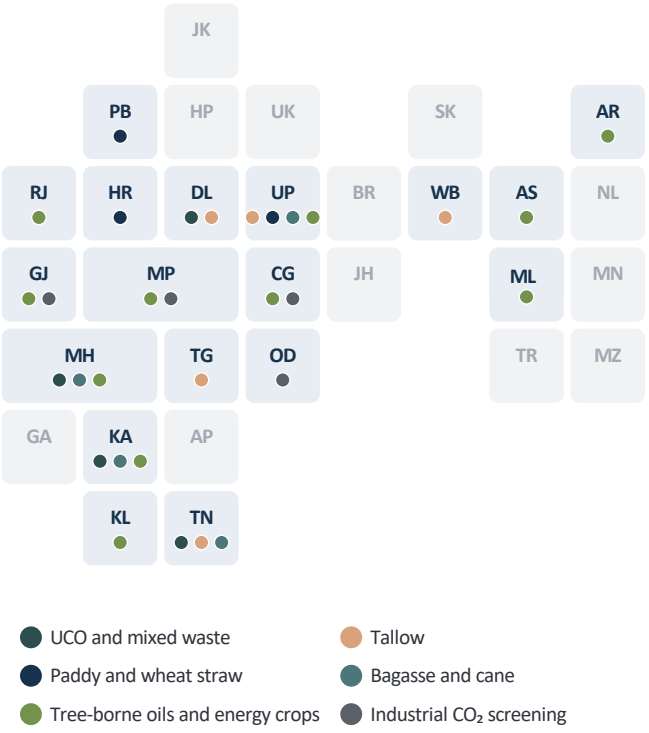
Cross-referencing. Field inputs were used to test secondary findings on collection practices, seasonal constraints, competing uses, infrastructure gaps and the difference between reported and mobilisable supply. Where field and data evidence agree, confidence is strengthened; where they differ, definitions, coverage and timing are examined before conclusions are drawn. Findings from a few locations are not generalised to every region.

What the field added. Street vendors discard UCO, some unaware it has value and others afraid that selling it feeds illegal resale. Growers in Uttar Pradesh and Telangana have no route into commercial biofuel chains. Haryana aggregators pile bales on leased land, cutting the next crop's yield by 30–40%. And 69% of Punjab farmers gave their straw away free in 2024.

Capability gaps. Regulatory and verification interviews found SAF-specific certification, MRV (measurement, reporting and verification) and lifecycle-assessment skills concentrated in a handful of institutions. DGCA requires National Accreditation Board for Certification Bodies (NABCB)-accredited verification bodies, and that pool is thin. Licensor training arrives only after a final investment decision, so it does nothing for the pre-approval bottleneck. Capability, not technology, sets the pace at which announced projects become delivered capacity.

Six questions for every location: its scale and seasonality; what is genuinely surplus; what collection and pre-processing it needs; how easily material can travel; how close it is to conversion and transport infrastructure; and whether quality, traceability and supply are consistent.

FIGURE 8 **Fieldwork and mapping geographies**



Source: Ohayo Green Energy fieldwork, 2026. Schematic tile map: each tile is a state or union territory, labelled with its two-letter code (listed under Abbreviations); not to scale and not a boundary map.

WHAT MAKES THIS STUDY DIFFERENT

Most feedstock estimates stop at national statistics. This study tested them on the ground, through **fieldwork across 10+ states, about 80–90 stakeholders** and prices taken from operators, so it reports on-ground realities and reflects current market dynamics.

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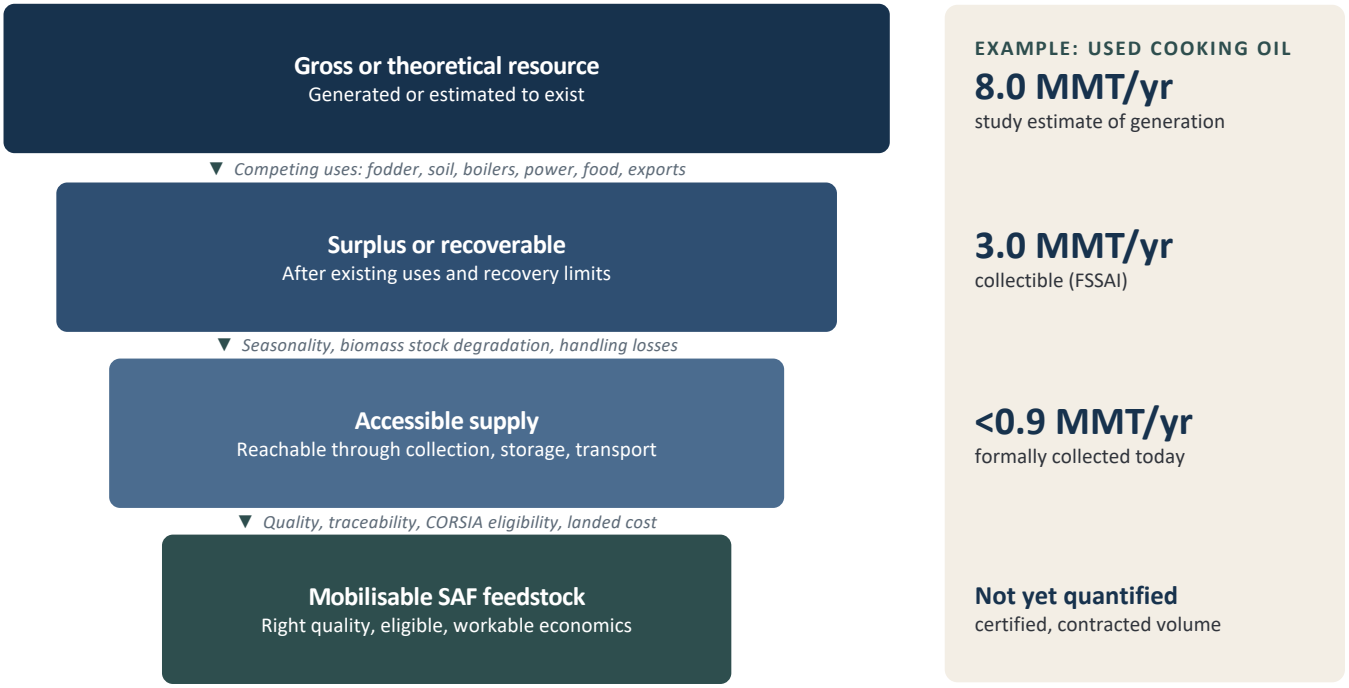
2.3 Accessibility filters: from resource to mobilisable feedstock

Most feedstock never reaches a plant: of ~8 MMT/yr of UCO generated, under 0.9 MMT is formally collected.

FIGURE 9 **Four stages of availability and the filters between them**



Source: Ohayo Green Energy methodology, 2026; UCO figures from the study estimate (8 MMT), FSSAI (3 MMT) and formal-collection share (<30%).

WHAT WE SAW IN THE FIELD

15–25%
of straw bales are lost when stored uncovered

Straw left in the open rots, is damaged by rain, or is burnt to clear fields for the next crop.

30–40%
lower yield on the next crop

Bales stacked on rented farmland cut the following harvest, and long storage on fields compacts the soil.

4 rival buyers
compete for the same straw

Fodder in the north, brick kilns for mustard straw, boilers around Ludhiana for paddy, and sugar mills burning their own bagasse.

WHY EACH FEEDSTOCK SHRINKS DIFFERENTLY

Crop residues	Also wanted for fodder, soil and power; must be baled in a short window; costly to move.
UCO and tallow	Depend on how much is collected, who has already bought it, and whether it can be traced.
Oil crops	Depend on suitable land, yields and the years a crop takes to mature.
MSW and industrial CO_2	Depend on what the waste contains, how well it is sorted, and whether capture is practical.

How we count. Each figure is filtered region by region, because straw spare in one district may be fully used in the next. Losses are subtracted only where the source study has not already done so, so nothing is counted twice. Where the evidence cannot support a firm number, we show it as potential, not confirmed supply.

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2.4 Sustainability safeguards: from mobilisable to certifiable feedstock

Securing sufficient volume and organising transport corridors represent only part of the equation for viable aviation feedstocks.

To achieve formal CORSIA certification, raw materials must also meet strict environmental, social, and economic requirements across every stage of their handling.

FROM THE POINT OF COLLECTION TO THE REFINERY



Transparent traceability *required at every stage*

Ethical labour practices *required at every stage*

Verifiable environmental safeguards *required at every stage*

Environmental

CROP RESIDUES · ENERGY CROPS

On the environmental front, collecting crop residues demands sustainable harvesting limits to safeguard soil fertility and organic carbon, while cultivating energy crops must avoid placing additional strain on water-stressed areas.

CERTIFICATION REQUIRES

- **Sustainable harvesting limits**
- **Soil fertility and organic carbon**
- **Strain on water-stressed areas**

Social

UCO · MSW

On the social front, aggregating UCO and MSW still relies heavily on unregulated or informal labour. Structuring these supply chains into formal operations is vital to guarantee fair wages, protect workplace safety, and support rural development without compromising local food security.

CERTIFICATION REQUIURES

- **Formal supply-chain operations**
- **Fair wages and workplace safety**
- **Rural development and local food security**

> **Ultimately, without transparent traceability, ethical labour practices, and verifiable environmental safeguards from the point of collection to the refineries, physically available feedstocks cannot be certified as Sustainable Aviation Fuel.**

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2.5 Carbon-intensity criteria and lifecycle assessment

Lifecycle emissions are assessed alongside availability and readiness, not as a final check. In India, hydrogen and power decide the result.

Standards applied: The working assessment draws on the GREET 2023 model (Argonne National Laboratory), ISO 14040, 14044 and 14067 as applicable, and ICAO's CORSIA documents. Each use discloses the model version, system boundary, functional unit, foreground inputs, allocation approach and sensitivity tests. Naming a standard does not establish conformity, independent review or certification.

Thresholds: Fossil jet fuel is benchmarked at 89.0 gCO_2e/MJ. CORSIA requires at least a 10% lifecycle reduction (80.1 g or less); EU Renewable Energy Directive III (RED III) and ReFuelEU require 65% (31.15 g or less). HEFA-UCO clears both: 13.9 g on the CORSIA default and 17.07 g on a harmonised inventory recalculated for the current Indian grid.

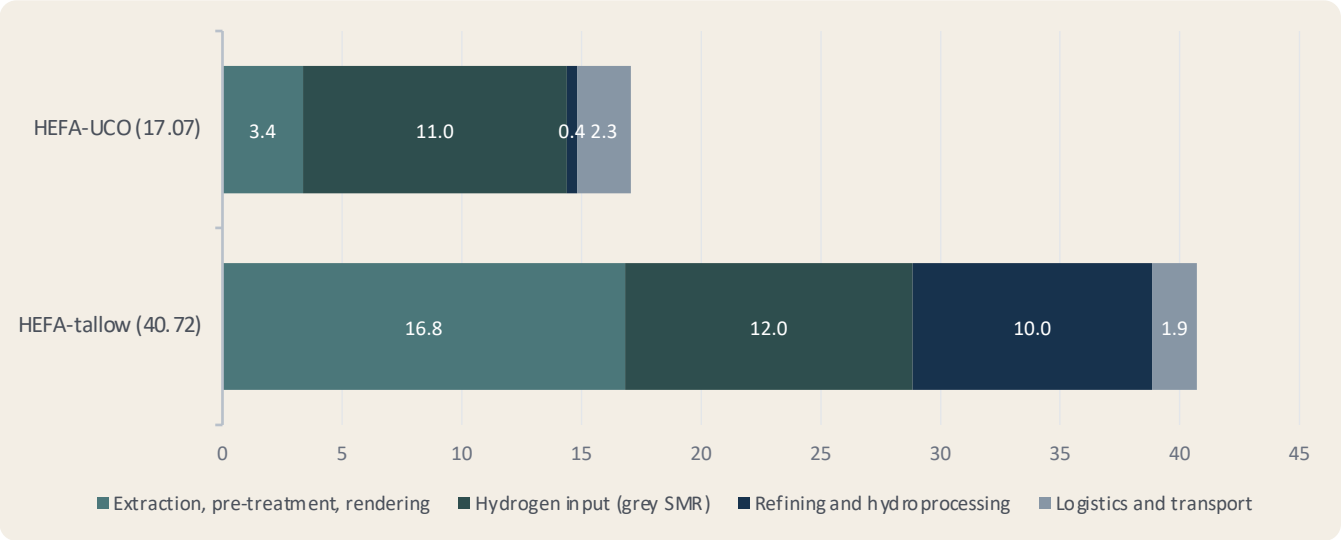
Where emissions sit: In the harmonised comparison by Yang and Yao, hydrogen supplies 64.6% of the UCO case (11.03 of 17.07 g) while refining adds only 0.43 g. Rendering supplies 41.3% of the tallow case (16.82 of 40.72 g).

Localising for India: High free-fatty-acid UCO (10–25% or more), higher hydrogen use (30–38 kg per tonne of oil), a grid at about 750 grams of CO_2e per kilowatt-hour (gCO_2e/kWh) and two-tier collection logistics add roughly 3.8–8.9 g over global defaults. Green hydrogen meeting the National Green Hydrogen Mission limit of 2.0 $kgCO_2e/kg$ removes 7–9 g, a net improvement of 1–5 g and brings HEFA-SAF to 5.85–9.30 g: an 89–93% saving on fossil jet.

Three kinds of evidence are kept apart: international benchmark values, India-specific modelled results and certified fuel-batch values. Eligibility is not technical suitability, and sustainability certification is not technical fuel qualification.

Data gaps to close: India lacks CORSIA-recognised, India-specific lifecycle baselines for domestic feedstocks such as bagasse, residues and UCO, which forces reliance on global default factors that do not reflect Indian collection, grid or hydrogen conditions. India-specific techno-economic data is similarly scarce. Fuel qualification under ASTM D4054 can take six to seven years or more; Indian laboratories have strong capability but no central intake body to coordinate them. Building these baselines is an opportunity for research institutions and verifiers.

FIGURE 10 **Where HEFA emissions accumulate: UCO versus tallow (gCO_2e/MJ)**



Source: Yang and Yao, Sustainable aviation fuel pathways: emissions, costs and uncertainty, Resources, Conservation and Recycling 215 (2025), harmonised inventory, as applied in the study. SMR: steam methane reforming, the conventional route to grey hydrogen.

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3 Mobilisable feedstock volumes, ranked by maturity

Where a resource sits, and who can reach it, matters as much as how large it is.

Used cooking oil comes from thousands of kitchens, crop residues follow harvest cycles, and industrial carbon is tied to individual plants. Each has a different road from resource to dependable supply.

This chapter takes the feedstocks in order of maturity, starting with the waste lipids that can use the established HEFA route and ending with industrial carbon. It is a sequence by readiness, not a certification ranking or a commissioning timetable.

For every feedstock the questions are the same: where is it, how much of it can realistically be reached, how carbon-efficient is it, what holds it back, what else competes for it, and where is the untapped potential?

Certified mobilisable tonnes are not available consistently at district level, so most figures describe resource or collection potential, and the text says which. The regional geographies named are where the assessment looked closely; they are assessment geographies, not priority locations for any single organisation.

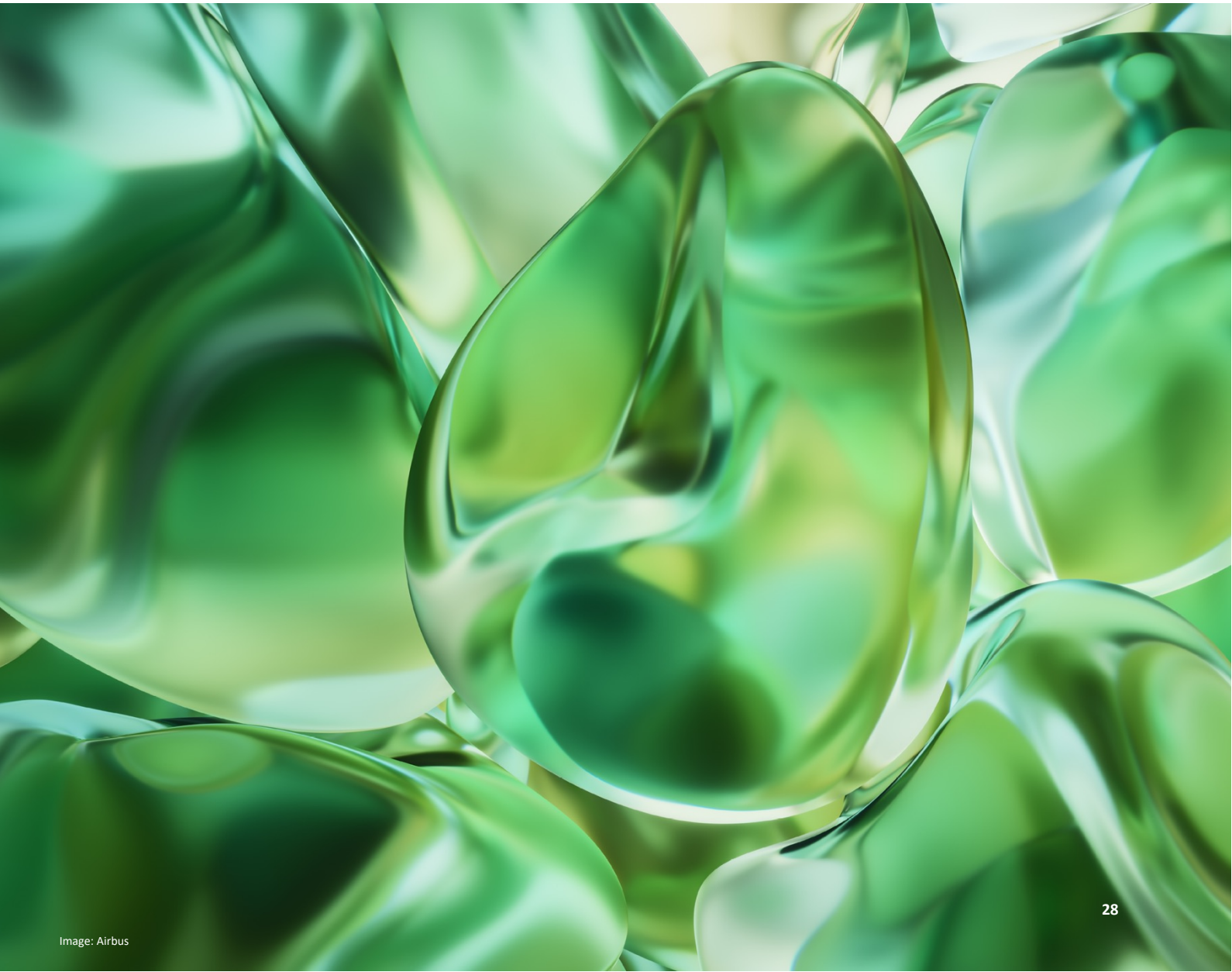

Image: Airbus

Six questions for every feedstock

Seven feedstock groups follow, each assessed against the same six questions. Below are select answers to these key questions for various types of SAF feedstock.

"For every feedstock the questions are the same: where is it, how much of it can realistically be reached, how carbon-efficient is it, what holds it back, what else competes for it, and where is the untapped potential?"

Where is UCO?

80%

of India's collectible used cooking oil sits in three city clusters: north, west and south.

How much UCO can realistically be reached?

<0.9 of 8 MMT

of used cooking oil generated each year is formally collected today.

How carbon-efficient is UCO?

13.9 vs 89 g

CO_2e per MJ: SAF from used cooking oil (CORSIA default) against fossil jet fuel.

What holds rice straw biomass back?

15–25%

of crop-residue bales are lost in uncovered storage. Storage and working capital are the binding constraints.

What else competes for biomass?

4 rival buyers

Fodder, brick kilns, boilers and sugar mills already bid for the same crop residues.

Where is the untapped potential for Biomass?

200–300 MMT/yr

of surplus crop residue: the largest pool, and the most investable medium-term opportunity.

Source: Sections 3.1–3.5 of this report; Ohayo Green Energy feedstock assessment, 2026; carbon values from CORSIA defaults.

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3.1 The maturity ladder at a glance

Readiness, not size, sets the order. The largest feedstocks sit lowest on the ladder, and what moves them up is evidence, not volume.

FIGURE 11 **Seven feedstock groups ranked by readiness to supply SAF in India, 2026**

MORE READY

	FEEDSTOCK AND PATHWAY	HEADLINE FIGURE	WHAT UNLOCKS IT
1	**Used cooking oil** HEFA, co-processing · TRL 8–9	**~3 MMT/yr** collectible UCO	Collection and traceability to stop food-chain leakage
2	**Animal tallow** HEFA · TRL 8–9	**Rendering clusters** organised processing capacity	Spare supply beyond soap and chemical buyers
3	**Tree-borne oils** HEFA · crop chains early	**~188,000 t** tobacco seed oil potential	Organised seed-collection networks
4	**Agricultural residues** AtJ, FT · TRL 6–8	**200–300 MMT/yr** surplus crop residue	Storage and working capital for aggregators
5	**Energy crops** HEFA · agronomy early	**~15 Mha** marginal and fallow land	Grower incentives and land safeguards
6	**Municipal solid waste** Gasification-FT · TRL 4–6	**170,939 t/day** MSW generated	Segregation at source to cut contamination
7	**Industrial CO_2** PtL, gas fermentation · TRL 4–6	**1,949 MMT CO_2e** industrial emissions (PAT)	Capture, green hydrogen and firm clean power

Near term, to 2030 · Medium term, 2030–40 · Medium to long term, 2030+ · Long term, 2040+

Source: Ohayo Green Energy feedstock assessment, 2026; carbon values from CORSIA defaults and the Yang and Yao harmonised inventory as applied in the study.

Size and readiness run in opposite directions. Waste lipids top the ladder because HEFA is proven, but collection caps their volume. Crop residues sit fourth yet form the largest pool, and only storage and working capital stand in the way. That makes them the most investable medium-term opportunity.

The cleanest routes are the least mature. FT on residues and PtL on renewable power have the lowest carbon intensity but are still developing. HEFA is ready, but its score depends on hydrogen and power: 13.9 g under the CORSIA default, 17.07 g on India's grid.

Evidence moves a feedstock up. Documented collection, contracted volumes, India-specific lifecycle values and a conversion route ready to receive it matter more than size. A tree-borne oil with an organised seed network and verified carbon performance could overtake a larger but uncollected resource.

A 2026 snapshot. The ranking reflects readiness today.

USING THE LADDER

Read the last column of the ladder as a list of opportunities: collection and traceability for lipids, seed networks for tree-borne oils, storage and finance for residues, segregation for MSW, and clean hydrogen and power for industrial carbon.

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3.2 Used cooking oil: estimated availability and geography

UCO is India's most mature SAF feedstock and its most leaky one. The limit is suitable, traceable oil, not the headline volume.

Estimated availability. India consumes about 27 MMT of fresh cooking oil a year; on that basis the study estimates UCO generation at about 8 MMT a year, and attributes a separate figure of about 3 MMT a year of practically collectible UCO to the Food Safety and Standards Authority of India (FSSAI). Under 30% of the collectible pool, less than 1 MMT, is formally collected today. The 8 MMT is a study estimate rather than an FSSAI statistic, and neither number is certified SAF supply.

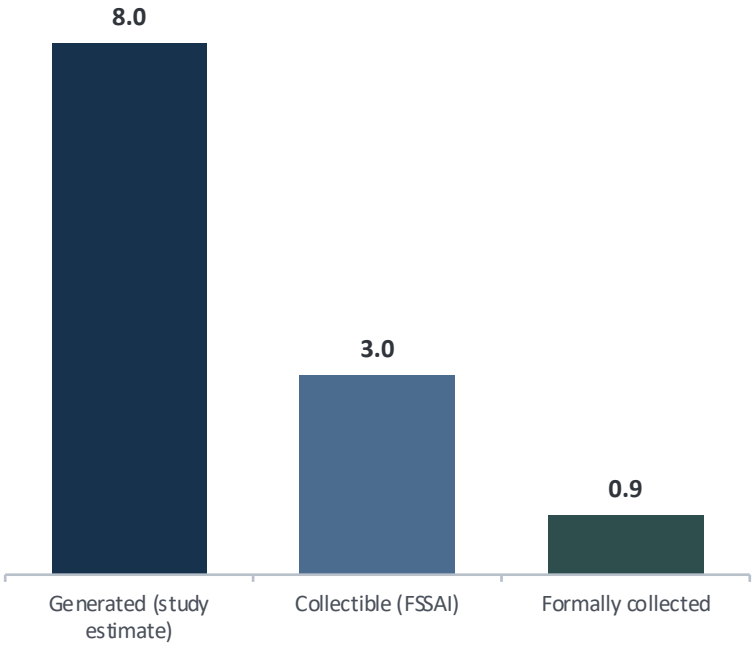
Geography. About 80% of collectible UCO is concentrated in three broad clusters (north, west and south) centred on Delhi, Mumbai, Bengaluru and Chennai. That is an indicative figure, not a measured regional split. City population is a poor guide: recoverable supply depends on how food-service activity and collection networks are organised. Tourism centres and institutional kitchens were also covered in the fieldwork.

Carbon efficiency. HEFA-UCO is the lowest-intensity near-term route: 13.9 gCO_2e/MJ on the CORSIA default and 17.07 g on the India-grid harmonised inventory, against 89.0 g for fossil jet. Logistics barely moves this. Urban feeder collection by light vehicles (about 250 gCO_2e per tonne-km) and regional trunking by tankers (about 100 g) add 1.13 g for a metro hub within 150 km and 8.19 g for a 1,650 km pan-India haul. With green hydrogen, even pan-India sourcing holds total intensity near 14.4 g, well inside the EU limit of 31.15 g, so catchments can be national rather than metro-bound.

Collection topology. Tier-1 collection is stop-and-go: light commercial vehicles with 1–3 t payloads visit restaurants, halwais and canteens. Tier-2 trunking moves pre-treated oil 300–1,500 km in multi-axle tankers. Pre-treating at the end of Tier 1 is what makes Tier 2 efficient.

Quality. Indian UCO typically carries high free fatty acids (10–25% or more) and polymers, raising pre-treatment needs and hydrogen consumption (30–38 kg per tonne of oil, against 25–30 kg for clean oil). Incoming specifications and suitable pre-treatment at spokes protect both conversion yield and the carbon result.

FIGURE 12 **From generation to formal collection: UCO in India (MMT per year)**



80%
of collectible UCO sits in three clusters: north, west and south

14.4 g
total CO_2e/MJ for pan-India UCO sourcing with green hydrogen

Source: Study estimate (generation), FSSAI (collectible), Ohayo Green Energy assessment (formal collection, under 30% of collectible).

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3.3 Used cooking oil: competing use and untapped potential

UCO is not an unclaimed waste stream. It has buyers, domestic uses and export channels, and these decide what SAF producers can reach.

FIGURE 13 **Three tiers of India's UCO market**

Market tier	Share	Price to generator	Where the oil goes	Traceability
Informal traders	~60%	₹25–30 per litre	Back into the food chain as spurious cooking oil; a public-health risk	None; illegal and unmonitored
Mid-sized aggregators	<30%	₹60–70 per litre	Domestic biodiesel and low-value soap manufacturing	FSSAI/RUCO registered; no digital ledgers
Large exporters	~10%	Global-linked	Certified feedstock to overseas SAF and renewable-fuel plants	High; CORSIA audit-ready

Source: Ohayo Green Energy primary research and market analysis, 2026. Shares are of collectible UCO and indicative.

Leakage: The study estimates that about 60% of collectible UCO re-enters the food chain through informal traders paying ₹25–30 a litre: lost feedstock and a public-health risk. Compliant aggregators pay ₹60–70 a litre and sell mainly into biodiesel and soap. Higher collection volumes add nothing to SAF supply if the extra oil is already spoken for.

Exports are allocated, not competed: In February 2024 the top five exporters handled 86% of UCO export volume, and the top three 71% of volume and 77% of value. One exporter converted 22% of volume into 41% of value, averaging US$2,455 a tonne against a US$1,290 Indian average: a 90% premium linked to certification, buyer relationships and destination control. Between May and July 2024 the top two destinations' share rose from about 38% to 56% while total volume barely moved. Under stress, access is rationed before prices adjust, so destination mix is the early warning of tightening supply.

Demand for traceability is high: Exports show that buyers will pay for certified, traceable Indian UCO. They do not show how much could be redirected to SAF at home; the real question is whether suitable volumes can be contracted and delivered consistently, with paperwork.

Challenges: Fragmented collection, patchy records and variable quality make verification harder and raise aggregation and pre-treatment costs. Traceability is a condition of eligibility, not an administrative step.

Untapped potential: lies in the informal 60% and in the roughly 70% of collectible oil outside formal channels. It should be reported only after existing market flows and quality exclusions are taken out.

WHAT THE MARKET DATA REVEALS

- **The compliant channel already pays double.** Kitchens selling to informal traders get ₹25–30 a litre against ₹60–70 from registered aggregators, so price alone does not explain the 60% leak.
- **Traceability is worth more than volume.** One exporter earns a 90% premium (US$2,455 against US$1,290 a tonne) from certification and market reputation, not from collecting more oil.
- **Watch where UCO goes, not what it costs.** When supply tightens, buyers ration access before prices move: the top two export destinations rose from 38% to 56% of volume in three months.

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3.4 Animal tallow: a second waste lipid for HEFA

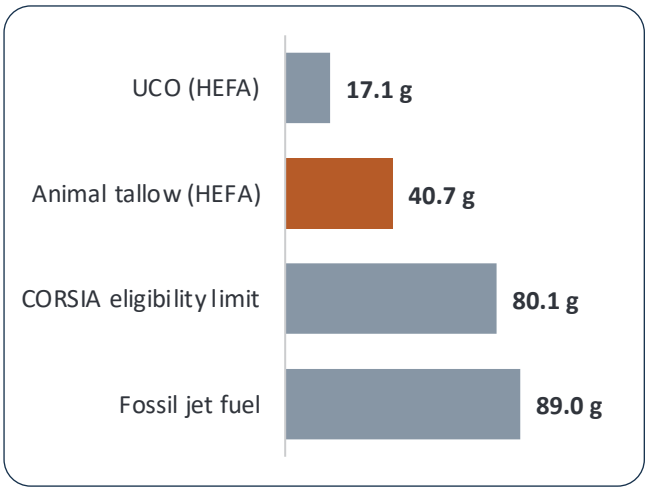
Tallow is ready for HEFA today. Its value lies in traceable supply, not new volume.

Estimated geographic availability. Tallow comes from rendering animal by-products, so availability follows organised slaughterhouses, meat processing and rendering capacity, not livestock numbers. Where rendering is organised (around Muzaffarnagar, Hyderabad and Kolkata) the starting point is stronger; fieldwork also covered Delhi and Chennai.

Competing use. Soap and chemical industries consume most domestic tallow, and exports concentrate in Malaysia and Nepal. Tallow prices correlate moderately with UCO (r = 0.45), and tallow exports did not rise during UCO deficits, indicating little spare capacity. Diversifying across waste lipids does not materially reduce SAF feedstock risk, because both markets share the same structure: high export concentration and controlled allocation.

Carbon efficiency. Rendering is energy-intensive. In the harmonised inventory HEFA-tallow reaches 40.72 gCO_2e/MJ against 17.07 g for UCO, with rendering contributing 16.82 g. It still clears the CORSIA threshold, by a smaller margin, and rendering energy is the lever.

FIGURE 14 Carbon intensity of HEFA from tallow against UCO, the CORSIA limit and fossil jet, gCO_2e/MJ



Source: Ohayo Green Energy market analysis (price correlation, export behaviour); Yang and Yao harmonised inventory (carbon intensity); CORSIA limit is a 10% saving against 89.0 g fossil jet.

Supply-side avenues. Formalise collection with organised renderers and meat processors; develop regional sourcing hubs around the three clusters; build chain-of-custody documentation from rendering plant to refinery gate, matching the audit standard already required of UCO exporters; and connect organised suppliers with SAF producers through pilot procurement. Formal supplier agreements reduce the price volatility and quality inconsistency that make tallow harder to plan around than UCO. The pace should track the UCO programme rather than outrun it.

Untapped potential. The opportunity in tallow is not new supply but traceable supply: organised rendering clusters already exist, and the gap is documentation and formal procurement from them. Fish oil appears in the medium-to-long-term lipid list, subject to the same tests of origin, competing use and eligibility.

Common standards. Industry associations can help establish shared traceability and sustainability standards across the rendering sector, so that an organised renderer in one cluster and a buyer in another speak the same documentary language. The expected outcome is a traceable, organised tallow supply that improves feedstock availability for HEFA while strengthening transparency across the lipid chain; the aim is to de-risk tallow, not to scale it beyond its supplementary role.

WHAT TALLOW CAN DO FOR SAF

1. **Add a second HEFA lipid**
   Supplements UCO in the same refineries and catalysts, with no new conversion route.

2. **Bring traceable supply to market**
   Organised renderers around Muzaffarnagar, Hyderabad and Kolkata already exist; the gap is documentation and procurement.

3. **Cut carbon at the renderer**
   Rendering energy is 16.82 g of tallow's 40.72 g, so cleaner heat is the main lever.

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3.5 Tree-borne oils: where the seed already grows

Six non-edible oils already grow in India's farms, plantations and forests. Few are counted as SAF feedstock; what is missing is the collection chain, not the oil.

FIGURE 15 **Six overlooked SAF oils: where they grow, oil content and indicative potential**

~318,000 t/yr of oil from tobacco seed, Chinese tallow and rubber seed alone: about a tenth of India's collectible UCO, with no new land or food conflict.

CROP BY-PRODUCT
Tobacco seed
0.45 Mha already under cultivation
~188,000 t/yr
38% oil · collect at grower level

INVASIVE TREE
Chinese tallow tree
Lower slopes of the northern Himalayas
~100,000 t/yr
40–50% oil and wax · harvest existing stands, do not plant

PLANTATION BY-PRODUCT
Rubber seed
Plantation belts of Kerala and Karnataka
~30,000 t/yr
40–50% oil (kernel) · no organised collection yet

FOREST OIL
Nahor (Mesua ferrea)
Assam, Arunachal Pradesh
Regional scale
40–60% oil · low food conflict

WILD TREE
Wild almond
Southern peninsula, eastern India
Not yet quantified
>50% oil · informal gathering today

FOREST PRODUCE
Mahua, sal, kusum
Forest belts with tribal produce systems
Not yet quantified
High oil · work through existing federations

Source: Ohayo Green Energy feedstock assessment, 2026. Indicative potentials show scale, not confirmed recoverable quantities.

Tree-borne and non-edible oils could widen the lipid base beyond waste oils, mainly for HEFA, without competing with food. Starting points differ: some seed is already generated by plantations or crop activity, while other sources need new cultivation or collection networks. Even where seed exists, the oil has to be recovered economically, in dependable volumes and in a suitable form.

Existing by-products first. Tobacco and rubber seed are the most immediate, because the seed is already produced. Rubber seed recovery is tied to the Kerala and Karnataka plantation belts and needs structured aggregator incentives with plantation bodies.

Forest systems. Mahua, sal and kusum have collection networks built over decades, but around other end uses (cocoa-butter equivalents, food and liquor) and with livelihood sensitivities. Scale-up should work through existing cooperatives, not parallel infrastructure.

Prioritisation. Pongamia, jatropha, mahua and sal are near-term priorities, with moringa, sapium and calophyllum further out. Seed that is not collected is not feedstock.

Livelihoods. Chinese tallow tree, with 40–50% combined oil and wax, and wild almond, with over 50% oil, are untapped rural livelihood opportunities where they already grow. Nahor and the forest oils are regionally capped by design; they are supplementary volumes, not a national HEFA base.


Image: Ohayo

WHO CAN BUILD THIS SUPPLY CHAIN

- **Aggregators and FPOs:** start with tobacco and rubber seed, already produced in known belts.
- **SAF producers:** early offtake will make seed collection worth organising for aggregators.
- **Forest federations:** add these oils to mahua, sal and kusum networks.
- **Government and researchers:** fund lifecycle data so the oils qualify.

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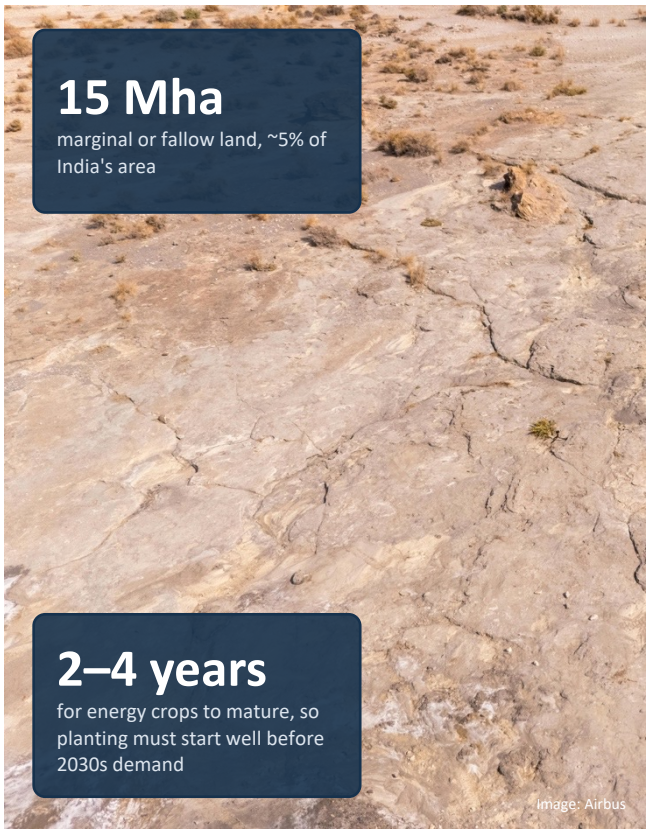
3.6 Energy crops and the fallow-land opportunity

Non-food oilseeds on marginal land could hedge the lipid market in the 2030s. The constraint is grower incentive, not hectares.

FIGURE 16 **Candidate crops and the land base**



Moringa
Prime alternate crop: matures in 2–4 years; seed oil 65–80% oleic, well suited to hydroprocessing

Carinata and camelina
Winter cover crops that fit wheat and mustard rotations without displacing food

Niger
Short-gestation oilseed better suited to local conditions than carinata or camelina, both of foreign origin

Cottonseed
Pragmatic near-term lipid using existing collection and crushing in Gujarat and Maharashtra

Source: Ohayo Green Energy feedstock assessment, 2026. Land figures are indicative and do not establish availability or suitability.

The land base. About 15 million hectares of marginal or fallow land, around 5% of India's land area, is identified as a potential base for non-food oilseeds, alongside 35–40 Mha of single-crop irrigated land where winter cover crops could fit existing rotations. This is an indicative opportunity, not proof that land is available or suitable.

Where. Arid Rajasthan holds large marginal-land pools and is a candidate for land screening, while densely populated Uttar Pradesh faces tight land constraints. Madhya Pradesh and Chhattisgarh are also in scope. Perennial options include mahua, neem, simarouba, jatropha, karanja and jojoba; annuals include camelina, carinata and pennycress.

Challenges. Land called marginal is not necessarily unproductive or free of other uses. Suitability depends on agro-climate, water, yields, tenure, livelihoods and the economics of cultivation and collection, and crop oils are not sustainable or eligible by category alone. Agronomic trials, water and land-use safeguards and existing food and industrial demand must decide.

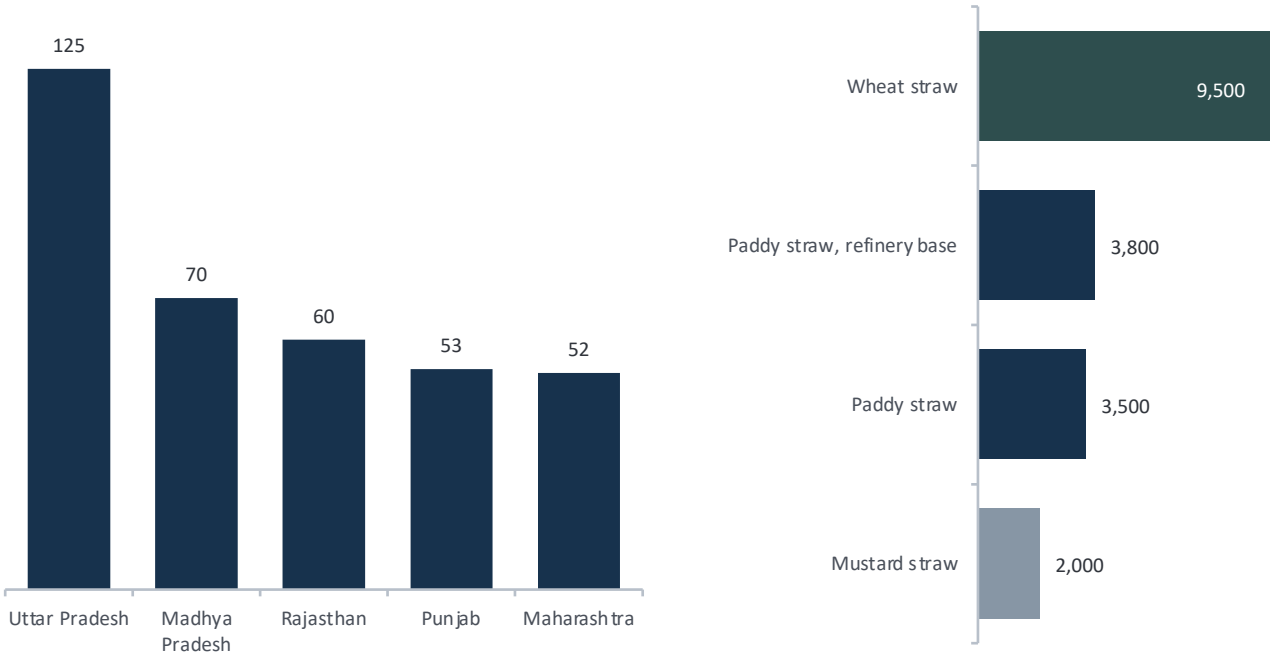
Regional programmes. The study identified Tamil Nadu, Kerala and Karnataka for Moringa and carinata planting-material programmes alongside rubber-seed networks, and Rajasthan, Uttar Pradesh, Madhya Pradesh and Chhattisgarh as the medium-to-long-term energy-crop belts.

Untapped potential. A food-neutral hedge against UCO prices, with rural income benefits, if planting material, buy-back arrangements and seed collection are in place before demand arrives. Crops that take two to four years to mature have to be planted well before the 2030s demand they are meant to serve.

3.7 Agricultural residues: the structural volume backbone

The only pool large enough to carry blending beyond waste lipids. Its constraint is aggregation economics, not availability.

FIGURE 17 **Biomass generation by state (MMT/yr) and open-market straw prices (₹ per tonne)**



Source: Biomass Atlas (National Institute of Bio-Energy, NIBE), as reported in the study; straw prices from Ohayo Green Energy fieldwork, 2026. Generation figures, not accessible surplus.

Estimated availability. India generates about 750T of biomass a year, and the study puts surplus at about 200–300 MMT: a broad estimate of surplus, not the amount that can be delivered to a plant. India is the third-largest generator of crop residue in the world, and rice, wheat and sugarcane make up about 53% of the lignocellulosic feedstock considered.

Geography. Five states (Uttar Pradesh, Madhya Pradesh, Rajasthan, Punjab and Maharashtra) generate 360 MMT, about 47.7% of gross national generation. Surplus is more concentrated: five states hold about 65% of surplus residue, which is what makes regional aggregation hubs viable. Punjab alone holds an estimated 22.25 MMT of surplus biomass. Punjab, Haryana and Uttar Pradesh form the straw belt. A national figure cannot say what is available in one plant's catchment.

Competing use sets the price. Raw paddy straw trades at about ₹3,500 a tonne (₹3,800 at one refinery's base), mustard straw at about ₹2,000 (brick-kiln co-firing) and wheat straw at about ₹9,500, reflecting fodder demand. Wheat straw is effectively spoken for; paddy straw is the SAF opportunity.

Four filters between surplus and supply. Competing uses (fodder, soil, industrial boilers, power); seasonality, as paddy straw arrives in October and November and must be baled within about 20 days; quality and losses, with 15–25% of bales lost in uncovered storage; and logistics and cost (distance, aggregation, densification).

Fragmentation. Holdings under 2 hectares dominate and over 90% of harvesting is informal, so centralised raw-biomass procurement is unviable; sourcing has to run through FPOs and state platforms.

A growing base. Food-grain production on the subcontinent has risen by about 605% since 1950, and residue has grown with it. The single October–November window for rice straw is the binding feature: long-term storage on fields compacts the soil and cuts the next crop's yield, so straw has to move off the farm quickly, and that is exactly the service an organised aggregator sells.

WHY PADDY STRAW NEEDS AGGREGATORS

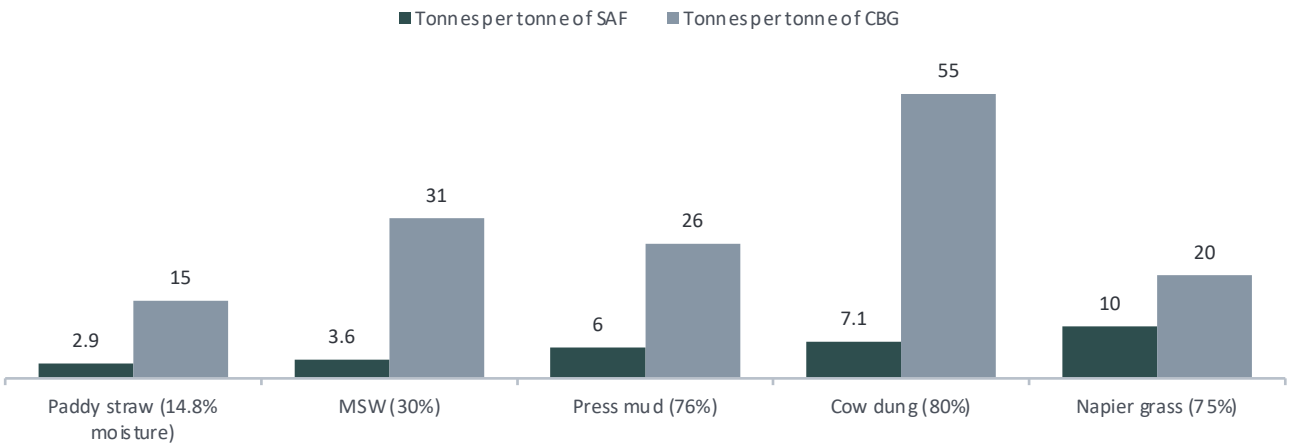
~65%
of surplus residue sits in five states

~20 days
to bale paddy straw after the harvest

3.8 Carbon efficiency: route by moisture, not by availability

Dry residues should be reserved for SAF and wet streams for biogas, or national carbon is wasted competing for the wrong feedstock.

FIGURE 18 **Tonnes of feedstock needed per tonne of fuel: SAF versus compressed biogas**



Source: Ohayo Green Energy carbon-efficiency analysis, 2026. Paddy straw shown at the upper end of its 1.7–2.9 t range.

The moisture penalty. High-moisture organic wastes need excessive drying energy in catalytic and gasification pathways, while in anaerobic digestion water serves as the process medium. Paddy straw at 14.8% moisture needs only about 1.7–2.9 t per tonne of SAF, against 15 t per tonne of CBG. MSW at 30% needs about 3.6 t for SAF. Press mud, cow dung and Napier grass carry severe drying penalties: 6.0, 7.1 and 10.0 t per tonne of SAF.

Carbon utilisation. Routing dry residues to SAF converts about 12% of feedstock carbon into fuel, against about 3% for CBG. A large biomass resource is not automatically a good SAF feedstock: moisture, conversion efficiency, collection needs and existing uses decide the right route.

Lifecycle performance. FT on agricultural residues has one of the lowest core footprints among international pathway benchmarks, about 7.7 gCO_2e/MJ. But straw's carbon performance has to be calculated from collection, preparation, transport and conversion inputs; being a residue does not settle it.

Policy competition. Ethanol-blending and CBG programmes already compete for paddy straw and bagasse. Demonstrating superior carbon conversion efficiency is the case for routing low-moisture residues to SAF, while leaving wet streams to biogas.

Implication for allocation. Straw is already contested by CBG, power co-firing, 2G ethanol and fodder. The priority for SAF is to identify suitable dry residues and their recoverable surplus, and to test wetter streams against biogas, which keeps the volume of biomass said to be available for aviation fuel realistic.

THE ROUTING RULE: MOISTURE DECIDES WHERE BIOMASS SHOULD GO

Dry residues
Paddy straw (14.8%), MSW (30%)

→ SAF

4×
more feedstock carbon reaches fuel: ~12% via SAF, ~3% via CBG

2.9 t
of paddy straw per tonne of SAF, against 15 t per tonne of CBG

Wet streams
Press mud, dung, Napier (75–80%)

→ BIOGAS

6–10 t
per tonne of SAF, because drying the feedstock uses up the energy

No drying
needed for biogas: in digestion, water is the process medium

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3.9 Ground truth from Punjab: four catchments, four stories

The residue chain breaks upstream of the refinery. The plant is not short of straw; it is short of straw that survived collection and financing.

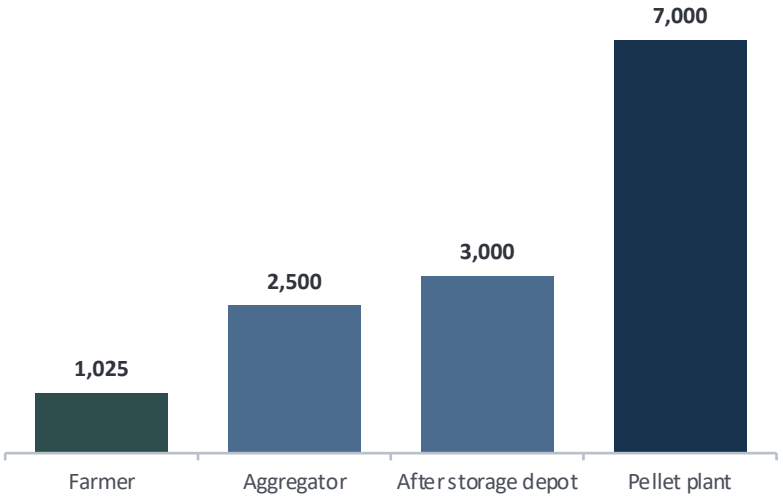
Within Punjab the assessment found four quite different situations, calling for different supply assessments. They are not a ranked list of where to act.

- **Sangrur, a proven catchment:** Where established buyers operate, active farm fires fell from 5,916 to about 290.
- **Bathinda, refinery anchor:** An upstream 2G-ethanol plant needs about 200,000 t of straw a year, secured within roughly 50 km.
- **Ludhiana, high competition:** Boilers pay ₹1,200–1,800 a tonne, so competition for straw is intense.
- **Tarn Taran, untapped potential:** Punjab's highest-burning district in 2025, with no formal aggregators.

Where the chain breaks. Farmers capture little value, so 69% gave straw away free in 2024 and burning stays the rational zero-cost choice. Over 90% of harvesting is informal and uncontracted, so farm-level chain of custody never starts. Open storage loses 15–25% of bales each year, about ₹90–130 million a season on a 300,000 t baseline. Aggregators need about ₹7.5 million up front to gather 5,000 t in the 20-day window, months before refinery payment, and borrow informally at 30%. One refinery's 2G plant has been held to about 62% of capacity by constrained feedstock intake.

Fixes that pay for themselves. Covered depots at ₹250–400 a tonne recover storage losses in the first season and double as traceability nodes. Invoice discounting against PSU purchase orders can cut aggregator borrowing from 30% to 10–11%. Named, written purchase agreements push aggregators to formalise. A benchmarked floor price would give farmers a reason to supply rather than burn.

FIGURE 19 **Punjab paddy-straw value cascade (₹ per tonne)**



15%
of the pellet value reaches the farmer

69%
of farmers gave straw away free in 2024

Source: Ohayo Green Energy fieldwork in Punjab, India, 2026.

CSR OPPORTUNITY

Balers and FPO capability in Bathinda, Sangrur and Tarn Taran, where offtake demonstrably cuts field fires, are fundable as CSR under Schedule VII, and deliver air-quality co-benefits alongside SAF feedstock.

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3.10 Sugarcane residues and bagasse: assess mill by mill

Mill aggregation helps logistics, but a bagasse heap is not evidence of uncommitted feedstock.

FIGURE 20 **Three sugarcane streams, three different availability tests**



Estimated geographic availability: Sugarcane residues and bagasse are another large part of the residue base, linked to cane-growing regions and sugar mills in Uttar Pradesh, Maharashtra, Karnataka and Tamil Nadu, where the fieldwork assessed bagasse. Rice, wheat and sugarcane together account for about 53% of the lignocellulosic feedstock considered.

Competing use: Bagasse is an established by-product of sugar processing and is already used within the industry, often for heat and power, while sugar and molasses are largely committed to first-generation ethanol and captive power. Its presence at a mill does not mean surplus is available.

Surplus should be assessed mill by mill after the plant's own heat and power needs, and any diversion has to show what energy it displaces, because that can change both lifecycle performance and practical surplus. Sugarcane trash and other field residues are collected and handled differently, closer to the straw model.

Climate and water. Monsoon variability moves cane yields and residue volumes, putting structural uncertainty into long-term planning, and large-scale sugarcane-based SAF would intensify irrigation demand in water-stressed basins. Residues, not purpose-grown cane, are the SAF opportunity.

The AtJ connection. Cane-belt and residue-belt ethanol is the upstream feedstock for Alcohol-to-Jet. A 2G-ethanol biorefinery in Bathinda, for example, is designed to process about 200,000 t of paddy straw a year into 100 kilolitres a day of advanced ethanol. Integrated mills cite unpredictable offtake rules, such as caps on grain-based ethanol allocation, as a reason to hold back on scaling; clear, long-term alcohol offtake would matter as much as feedstock.

Other biomass streams. Press mud, cow dung and Napier grass show why a large biomass resource is not automatically a good SAF feedstock: their high moisture means drying penalties, and they may suit compressed biogas better (see 3.8).

OPPORTUNITY

Mills with efficient cogeneration may free bagasse surplus, and cane trash can use the same baling, depot and FPO model as straw. Existing mill aggregation is a logistics advantage worth building on.

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3.11 Municipal solid waste: usable composition is what counts

MSW is a feedstock India already collects and pays to dispose of. The constraint is segregation and contamination, not volume.

FIGURE 21 **MSW in numbers**

170,939 t	~15 MMT	~3.6 t	US$1,631	None
generated every day nationally (~62 MMT a year)	of carbon a year contained in MSW	of MSW (30% moisture) per tonne of SAF	per tonne of SAF, gasification-FT on MSW (indicative)	Indian MSW-to-SAF facilities operating today

MSW could feed thermochemical routes such as gasification followed by Fischer–Tropsch synthesis. National generation of about 170,939 t a day shows the scale of the waste stream, not what is available for SAF. What matters is the fraction that can be recovered, prepared and delivered in a suitable, consistent form.

What would make sense geographically. Large cities produce large volumes, but differences in composition and preparation infrastructure change what can be mobilised, so screening should look at defined urban catchments rather than city size. Urban and tourism-centre sources were part of the fieldwork.

Filters and challenges. Composition, organic content, moisture, contamination and the quality of collection and segregation decide the usable fraction. India already collects much of its waste; it does not separate it to a standard any conversion plant can accept, and the organic fraction carries heavy plastic contamination. The assessment separates waste generated, waste collected, the fraction suitable for the chosen process and the quantity realistically recoverable for fuel. Biogenic content must be separated from fossil-derived material for fuel classification and lifecycle accounting.

Competing use. Material already committed to recycling should be deducted, and wetter organic fractions may be better routed to biogas.

Carbon efficiency. At around 30% moisture, MSW needs about 3.6 t of waste per tonne of SAF, against about 31 t per tonne of CBG, so the drier, segregated fraction is better suited to thermochemical fuel routes than to digestion. The carbon content (about a quarter of MSW mass) is what the gasification route captures, but only the biogenic share counts towards a renewable fuel.

Economics. Gasification-FT on MSW is the most capital-intensive route assessed, about US$19,577 per tonne of annual capacity, yet its indicative production cost of US$1,631/t is below that of residue-based AtJ and FT, because the feedstock itself carries little or no purchase cost.

Untapped potential. The study ranks MSW lower for the near term because preparation is complex and the organic fraction is relatively low. That is a constraint, not a lack of potential. Given heterogeneity, fossil plastics and logistics, MSW gasification is best treated as a post-2035 option; but unlike crop residues it offers a continuous, non-seasonal stream, and every tonne diverted eases landfill pressure.



FOR MUNICIPALITIES AND WASTE OPERATORS

Back source segregation and material recovery, not more collection. A clean, consistent organic stream is what turns MSW from a municipal liability into a SAF feedstock, which makes it a municipal problem before it is a technology one.

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3.12 Carbon Capture, Use and Storage (CCUS): conditional

India does not need a new inventory to find capture-ready CO_2. It needs end uses for it, and the clean hydrogen and power to make fuel.

Exploration phase. Industrial carbon is a different kind of opportunity. Emissions sit at identifiable plants, which allows a geographically focused assessment, and BEE's Perform, Achieve and Trade (PAT) scheme already registers, meters and reports India's largest emitters as Designated Consumers.

Scale. The PAT scope covers 1,949 MMT CO_2e, of which power, iron and steel, and cement account for about 1,670 MMT; power alone emits about 1,200 MMT, nearly five times the next sector. This is an emissions base, not capturable CO_2, and may include scope-2 accounting; usable quantities have to be established plant by plant.

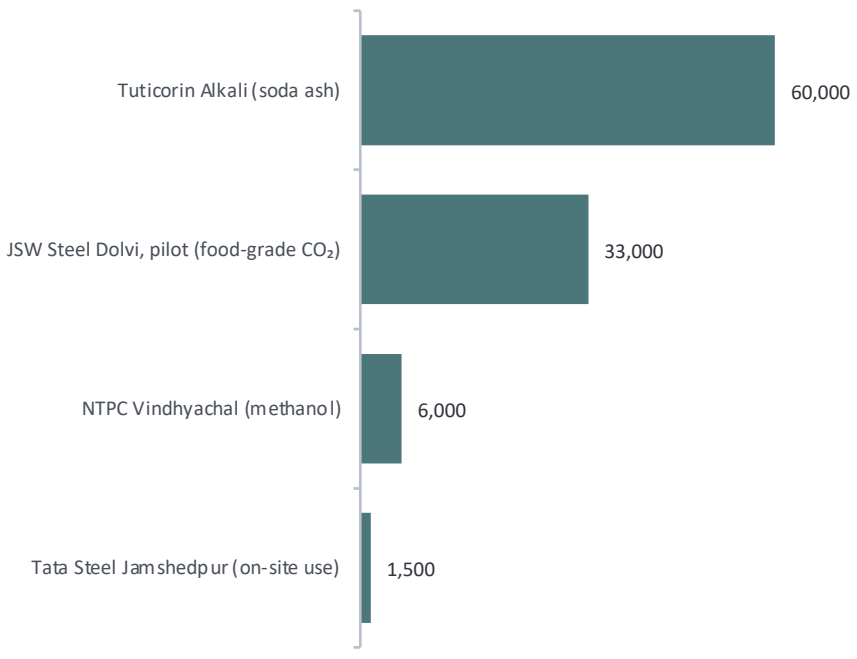
Who is in scope. PAT covers thermal power plants, iron and steel plants, aluminium smelters, distribution companies and petroleum refineries. Across sectors with reported data, about 79% of emissions are scope 1 and 21% scope 2, and only scope-1 point sources are physically capturable.

Relevant industrial corridors. The study identifies industrial belts in Odisha, Chhattisgarh, Gujarat and Madhya Pradesh for carbon-source screening. These are screening geographies, not approved project corridors.

Capture today. Operating and pilot capture is measured in tens of thousands of tonnes, and none of it currently becomes fuel. Storage pilots include CO_2 injection for enhanced recovery at Gandhar and a 1,200 m dedicated storage well at Pakri Barwadih.

The hydrogen link. Every CO_2-to-fuel route is really a hydrogen route. On a grid at about 750 gCO_2e/kWh, even a 5% grid top-up lifts electrolytic hydrogen to 3.54 $kgCO_2e/kg$, breaching the National Green Hydrogen Mission's 2.0 kg limit; only firm round-the-clock green power at 75–85% load factor holds the line. The same PtL route spans 7.0 to 279 gCO_2e/MJ depending only on the power source. Industrial carbon should therefore be planned with the Green Hydrogen Mission and the CCUS agenda, as a long-term option and an energy-security hedge. A green-hydrogen cost threshold is the practical trigger that would move e-SAF from watch-list to investment case; an 1,800 t/yr e-SAF pilot in Andhra Pradesh, converting CO_2-derived ethanol to jet, is an early test.

FIGURE 22 India's operating and pilot CO_2 capture-and-utilisation plants (t of CO_2 a year)



1,949 MMT
CO_2e in PAT scope

~0.1 MMT
captured a year across the four plants shown

Source: Ohayo Green Energy CCU review, 2026, based on public disclosures. None of the captured CO_2 currently goes to fuel. NTPC: NTPC Limited, formerly National Thermal Power Corporation.

3.13 What the feedstock evidence adds up to

Every feedstock group has the same gap: between a resource that exists and a volume that can be documented and delivered. These are the places where that gap can be closed first.

FIGURE 23 **Where to look, what to build and the evidence behind each opportunity**

Feedstock group	Where to look	What to build	Evidence from this chapter
Used cooking oil	Delhi, Mumbai, Bengaluru and Chennai clusters	Formal collection, pre-treatment and chain of custody for the ~60% now sold to informal traders	Certified exporters earn a 90% premium: US$2,455 vs US$1,290 a tonne
Animal tallow	Rendering hubs in Muzaffarnagar, Hyderabad and Kolkata	Rendering-to-refinery documentation and pilot procurement	40.72 g; rendering adds 16.82 g and is the lever
Paddy straw	Punjab, Haryana, UP; Tarn Taran-type districts with no aggregators	Covered depots, harvest-window finance and FPO sourcing	Depots at ₹250–400/t repay in one season; invoice discounting cuts borrowing from 30% to 10–11%
Bagasse and cane trash	Sugar mills in UP, Maharashtra, Karnataka and Tamil Nadu	Mill-by-mill surplus audits; cane trash collected on the straw model	Surplus exists only after each mill's own heat and power
Tree-borne oils	Rubber belts in Kerala and Karnataka; tobacco belts; forest cooperatives	Seed collection through FPOs and forest federations, triggered by early SAF offtake	~188,000 t tobacco seed oil potential
Energy crops	Rajasthan land screening; Moringa and carinata in Tamil Nadu, Kerala, Karnataka	Agronomic trials, then planting 2–4 years ahead of 2030s demand	~15 Mha marginal or fallow land (indicative)
Municipal solid waste	Defined urban catchments	Source segregation and material recovery for gasification-FT	~3.6 t per t SAF vs ~31 t per t CBG; no Indian plant operating
Industrial carbon	Odisha, Chhattisgarh, Gujarat and MP industrial belts	CCU offtake at hubs paired with firm green power	PtL spans 7–279 g on power source alone

Carbon values in gCO_2e/MJ. Highlighted row: the largest medium-term opportunity (see 3.1). Palm-derived oils are supplementary only, subject to origin and eligibility checks. Source: Ohayo Green Energy feedstock assessment, 2026; figures from sections 3.2–3.12.

THREE FINDINGS THAT CUT ACROSS FEEDSTOCKS

1
Route biomass by moisture

- **Dry straw suits SAF:** at 14.8% moisture, each tonne of SAF needs 1.7–2.9 t of paddy straw.
- **Biogas consumes more:** each tonne of CBG needs 15 t of straw.
- **Routing is efficient:** about 12% of feedstock carbon becomes fuel, against 3%.

2
Hubs need firm clean power

- **Grid power adds carbon:** HEFA-UCO rises from 13.9 g to 17.07 g on India's grid.
- **PtL rests on power:** 7 to 279 g on power source alone.
- **Small top-ups breach limits:** 5% grid power exceeds the Green Hydrogen Mission's 2.0 kg cap.

3
New oils are largely untapped

- **The seed exists:** tobacco and rubber seed are by-products, so no new land is needed.
- **Collectors exist:** FPOs and forest federations can add these oils.
- **A food-neutral UCO hedge:** three oils equal ~10% of collectible UCO.

WHAT THE SAF CHAIN WILL NEED

Collection, aggregation, pre-treatment, covered storage, chain of custody and harvest-window finance. These services, not new resource surveys, close the gap. Chapter 4 tests which conversion pathways can take these feedstocks; Chapter 5 sets out the hubs that would aggregate them.

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The biomass is already here. What India now has to build is the road from field to refinery gate.

The Feedstock Mobilisation Section Takeaway

4 Production outlook by technology readiness and pipeline

Having enough feedstock is only the starting point. Output depends on pathway maturity, project delivery and qualifying fuel.

How much SAF India can actually produce, and how fast, depends on the conversion pathway, how mature the technology is, whether projects get built, and whether the fuel meets technical and sustainability standards.

India's feedstock base points to several routes. Waste oils and animal fats can feed established lipid-processing pathways. Agricultural residues and other biomass could supply Alcohol-to-Jet and gasification-based conversion. Industrial carbon streams, combined with low-carbon hydrogen and electricity, offer a basis for synthetic fuels over a longer horizon. These routes complement each other, but they are not interchangeable.

This chapter reads the outlook through three questions: which pathways suit the resources India has; how ready the technologies and individual projects are; and how the announced pipeline compares with possible demand. Readiness is judged on three separate dimensions: the maturity of the conversion technology, the status of the specific project, and the ability to produce fuel that meets technical and sustainability requirements.



Image: Airbus

4.1 Pathways by horizon: from HEFA to power-to-liquid

HEFA for immediate deployment; AtJ and FT for the medium term; PtL and gas fermentation as the long-term frontier.

FIGURE 24 **Five production pathways matched to India's feedstocks**

SHORT TERM HEFA	SHORT TERM Co-processing	MEDIUM TERM Alcohol-to-Jet	MEDIUM TERM Gasification-FT	LONG TERM PtL and gas fermentation
INPUT UCO, tallow, tree-borne oils	**INPUT** Waste lipids in existing refinery hydrotreaters	**INPUT** Ethanol from sugar, starch or cellulosic residues	**INPUT** Agri and forest residues, selected MSW	**INPUT** Captured CO_2 plus green hydrogen and power
PROCESS Hydrotreatment and isomerisation	**PROCESS** Fastest, lowest-capex early volumes	**PROCESS** Dehydration and oligomerisation	**PROCESS** Syngas, then Fischer–Tropsch synthesis	**PROCESS** Electrolysis, synthesis or fermentation
TRL 8–9	**TRL 8–9**	**TRL 6–8**	**TRL 6–8**	**TRL 4–6**

Source: Ohayo Green Energy pathway assessment, drawing on IEA Bioenergy Task 39 and ASTM D7566. Horizons indicate broad sequencing, not commissioning dates.

Short term: HEFA for immediate deployment. HEFA hydrotreats suitable lipids into hydrocarbon fuel. It is proven commercially worldwide, the only fully commercial pathway available in India, and can use existing waste-lipid resources and refinery infrastructure, mirroring the projects already running or due shortly. Refinery co-processing is the fastest, lowest-capex route to early volumes, within each refinery's configuration and fuel qualification limits; co-processed volume is not the same as qualifying SAF.

Medium term: AtJ and FT. AtJ converts alcohols into jet-range hydrocarbons, and India's ethanol industry gives it a foundation, but an operating ethanol plant does not by itself establish SAF capacity. Gasification-FT turns residues and selected waste into syngas and then liquid fuel, reaching resources lipid routes cannot. Both depend on integrated chains linking feedstock, intermediates and conversion, and their scale-up has to be judged from whole-project performance.

Long term: PtL and gas fermentation. PtL combines captured carbon with electrolytic hydrogen, so its performance is set by the carbon intensity of electricity. Gas fermentation may convert carbon-containing gases into SAF intermediates. A pilot or announced project is not evidence of commercial output.

Indigenous technology. India has its own HEFA know-how: CSIR-Indian Institute of Petroleum (CSIR-IIP)'s single-step hydroprocessing technology produced more than 14,000 litres at pilot scale, validated by the Indian Air Force for 10% blends on An-32 transport aircraft, and underpins a refinery demonstration plant. Adapting processes to Indian feedstock can lower plant capex and reduce dependence on imported pathways.

Lock-in risk. Early focus on ethanol-based AtJ and UCO co-processing makes sense because it uses existing assets, but it could lock in less optimal routes if biomass- and power-based synthetic fuels mature and outperform on cost and carbon. Keeping demonstration options open hedges that risk.

A sequencing question, not either/or. One industry view holds that AtJ is the only route to national scale; another that HEFA is the only realistic route to near-term targets. The evidence supports both: HEFA de-risks early blending while AtJ and FT are built on the residue base.

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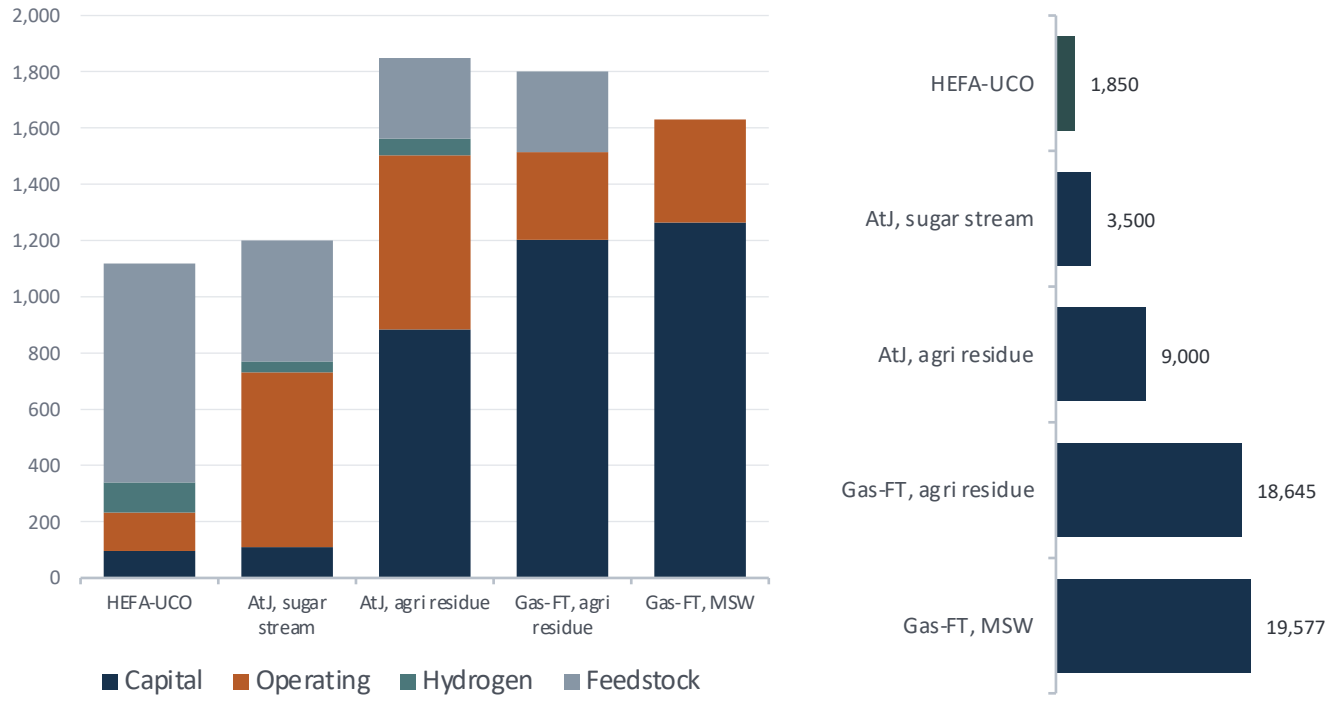
4.2 Indicative pathway economics

Capital intensity spans tenfold across pathways, but capex does not dictate production cost. Feedstock does.

FIGURE 25 **Production cost by component (US$ per tonne of SAF) and capital cost (US$ per tonne of annual capacity)**



Source: World Economic Forum, Clean Skies for Tomorrow: India Report (2021), as cited in the study. Indicative benchmarks, not current project quotations or bankable India-specific estimates.

Capital intensity. About US$1,850 per tonne of annual capacity for HEFA-UCO, US$3,500 for AtJ on sugar streams, US$9,000 for AtJ on residues and US$18,645–19,577 for gasification-FT on residues and MSW. A domestic benchmark points the same way: CSIR-IIP gives an indicative US$120 million (about ₹10 billion, ±30%) for a 30,000 t/yr plant.

Production cost. HEFA-UCO is cheapest at about US$1,117 a tonne, but US$778 of that is the UCO itself, so its economics stay exposed to feedstock price and access. Long-term feedstock contracts do more for HEFA than further capex optimisation. Gasification-FT on MSW lands at US$1,631 a tonne despite the highest capex.

The price ceiling. Market evidence suggests SAF cannot realistically price above 2–2.5 times conventional ATF; 2G ethanol already trades at more than twice 1G ethanol. Every intervention should be judged on whether it lowers landed feedstock cost, not just whether it raises collection volume.

Four risks that lenders price. Feedstock risk, because feedstock is most of operating cost and established industries compete for it; demand risk, because SAF costs more than fossil jet in a price-sensitive market where voluntary demand is still low; payback risk, because concept to stable cash generation takes 5–8 years; and policy risk, while SAF-specific instruments are still taking shape. Together they keep debt on the sidelines until projects are close to commercial operation, which is why de-risking feedstock supply has outsized value.

People and skills. A standalone SAF plant is a small direct employer, roughly 100–300 people; integrated-refinery figures are site-wide and not comparable. The scarcer resource is the certification, MRV and lifecycle-assessment capability around the plant, which approval timelines depend on and which additional capital does not by itself relieve.

Co-products and time. Hydroprocessing co-products (renewable diesel, bio-naphtha, bio-LPG) can lift first-of-a-kind plant IRR by 15–20%. Co-product markets also diversify revenue away from a single fuel price.

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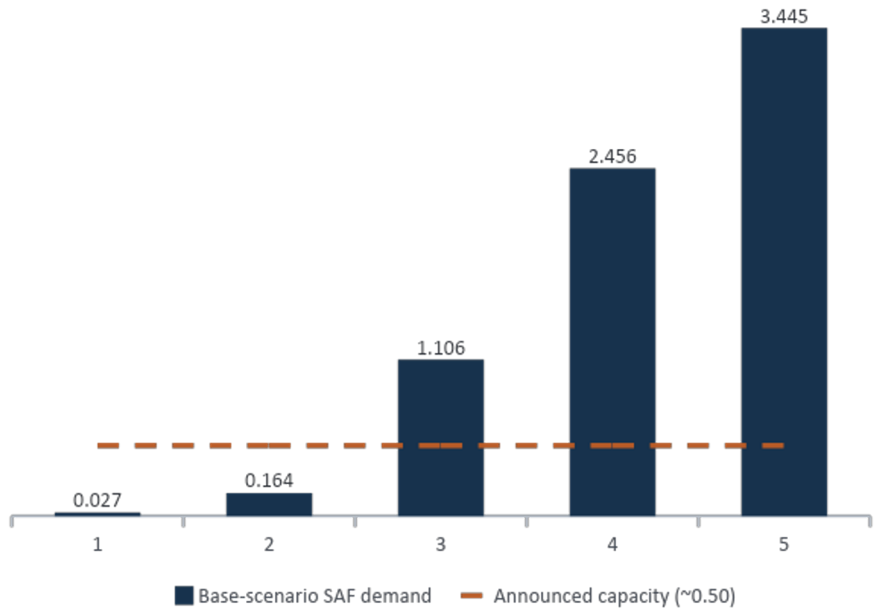
4.3 SAF demand projections against the pipeline

Demand could rise nearly sevenfold between 2030 and 2035 as blending extends to domestic flying, implying a production base far larger than today's pipeline.

FIGURE 26 **Indicative SAF demand, base scenario, versus announced capacity (MMT per year)**



COMMERCIAL BIOREFINERIES NEEDED (250,000 t each)

4–5
plants by 2035

~10
plants by 2040

14–20
plants by 2045

Source: Ohayo Green Energy demand model, base scenario: international blending 1% (2027) to 5% (2030); domestic from 1% (2031) rising one point a year to 10% (2040). Modelling assumptions, not an adopted mandate.

The fuel base. The demand model starts from 8.985 MMT of ATF in FY2024–25 (73% domestic, 26% international, 1% defence) and uses traffic-growth anchors of 6.2–8.9% a year. ATF demand reaches about 12.1–13.8 MMT by 2030 and 29.9–49.4 MMT by 2045. Fuel grows more slowly than passenger traffic, as fleet renewal and air-traffic management improve efficiency.

Base scenario. SAF demand rises from about 27,000 t in 2027 to 164,000 t in 2030, then to 1.1 MMT by 2035 as domestic blending begins, 2.5 MMT by 2040 and 3.4 MMT by 2045, with about 23.5 MMT needed cumulatively over 2026–2045. Conservative and accelerated cases give a 2045 range of 2.96–4.89 MMT: an uncertainty envelope, not a prediction. The scenarios do not factor in further gains from more fuel-efficient aircraft or improved air-traffic management, which would lower absolute demand.

International first. CORSIA exerts a stronger early pull on international flying, which is likely to adopt SAF faster than domestic segments during 2027–2035.

Calibrated against FY2024–25 data, an international movement burns about 5.02 t of fuel against 2.71 t for a domestic one, reflecting average stage lengths of about 3,240 km and 904 km. Because domestic aviation is 73% of civil fuel, domestic SAF overtakes international SAF by about 2033–34 once domestic blending begins.

Against the pipeline. For 2030 the announced 0.50 MMT exceeds base demand of 0.164 MMT, but that is not evidence of surplus: announced capacity is planned output, and only commissioned plants producing eligible SAF count as supply. By 2035 demand is well above the headline pipeline.

What scale implies. At 250,000 t per plant, the base case needs about 4–5 commercial biorefineries by 2035, about 10 by 2040 and 14–20 by 2045, drawing an estimated 4.9–7.0 MMT of raw feedstock a year at commercial HEFA and AtJ yields; lower-yield routes need more. That is the case for building aggregation now.

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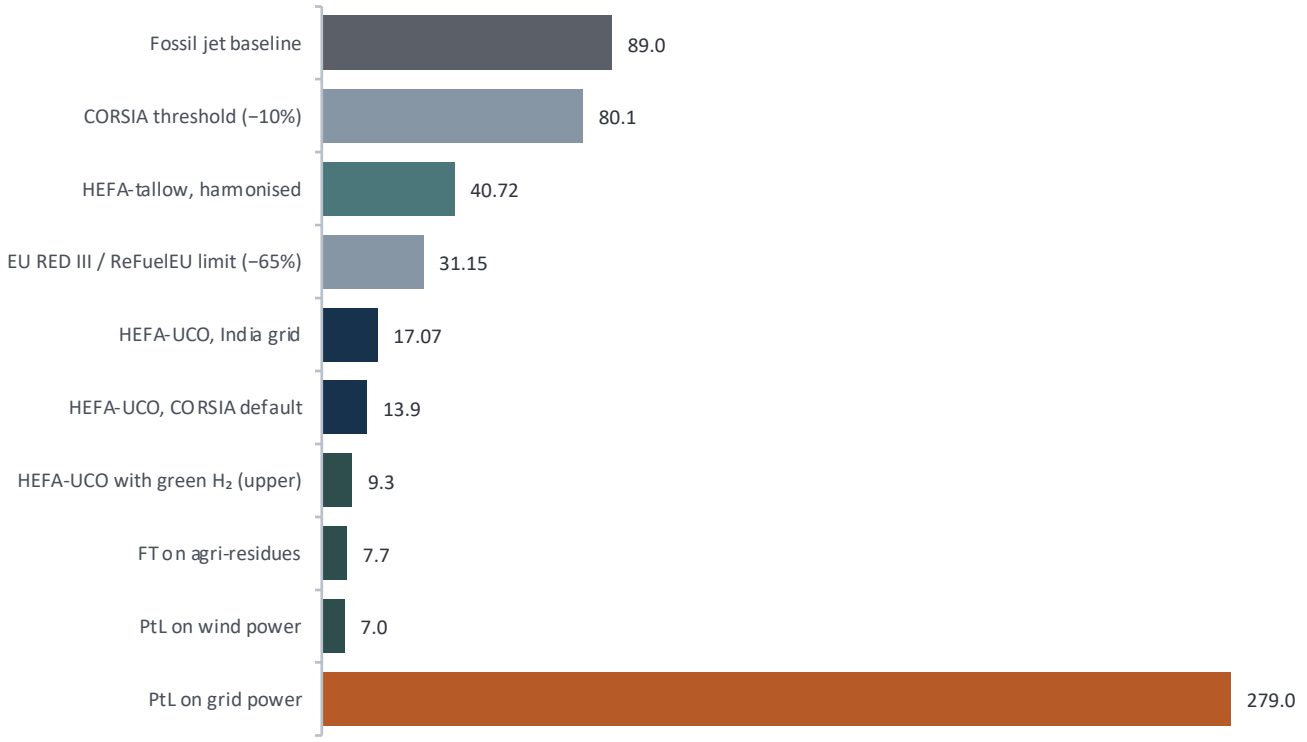
4.4 Carbon intensity by pathway: inputs decide compliance

The same pathway can pass or fail depending on its hydrogen and power. Production planning has to secure clean inputs, not only capacity.

FIGURE 27 **Lifecycle carbon intensity of selected pathways against thresholds (gCO_2e/MJ)**



Source: ICAO CORSIA default lifecycle values (2022); EU RED II/III parameters; Yang and Yao harmonised inventory; Ohayo Green Energy India localisation. Grid-powered PtL (279 g) is shown at full scale.

Thresholds are clearable. HEFA-UCO already clears both the CORSIA threshold and the EU's 65% reduction requirement, whether at the 13.9 g CORSIA default or 17.07 g on the India-grid harmonised inventory. Tallow clears CORSIA but not the EU limit, because rendering is energy-intensive.

Hydrogen is the lever. Grey hydrogen is 64.6% of HEFA-UCO's footprint. Back-calculation from facility targets of 500–600 $kgCO_2e$ per tonne of SAF implies operating plants already use hydrogen at 4.5–8.5 $kgCO_2e/kg$, hybrid grey and blue rather than unabated reforming. Meeting the National Green Hydrogen Mission's 2.0 kg standard cuts HEFA-SAF to 5.85–9.30 g; yield slippage from 1.739 to 2.30 t of UCO per tonne of SAF sharply tightens the hydrogen budget.

Power is the risk. Grid-connected PtL without dedicated renewables reaches 279 g, more than three times fossil jet. Firm round-the-clock green open access at 75–85% load factor (hybrid wind and solar with storage or hydro) is the single largest carbon-intensity lever.

For HEFA the margin is wider: even with a 10–20% grid blend in electrolysis, HEFA-SAF reaches 11.3–16.7 g and still passes the EU limit, though the hydrogen would no longer meet India's green standard.

Implications for the production base. Near term, lipid-based and refinery-linked production gives the clearest basis, if feedstock is secured and fuel is compliant. Medium term, AtJ and FT can broaden the base, judged on integrated project performance. Longer term, PtL adds diversity once clean energy, hydrogen and carbon sources align. Across all horizons, production potential comes from feedstock, pathway, infrastructure, workable economics and verified output together.

THE HYDROGEN LEVER, HEFA-UCO (gCO_2e/MJ)

17.07 g grey hydrogen today → **5.85–9.30 g** with green hydrogen

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The technology is ready. What the ecosystem needs now: plants built, capital committed, offtake signed and fuel that qualifies.

The Production Outlook Section Takeaway

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5 Flagship hubs and hub-and-spoke logistics

For a resource spread across thousands of farms, kitchens and rendering sites, SAF is a logistics problem before it is a technology problem.

Feedstock only becomes fuel if it can be collected, prepared and delivered to a plant that can convert it. This matters most for agricultural residues, which are generated across dispersed locations, have low bulk density and arrive in seasonal cycles.

India's feedstocks differ in where they are, how accessible they are, what else they are used for and how well they suit conversion, and those differences shape supply-chain design. Waste oils need organised collection, careful handling and traceability. Residues need coordinated harvesting, pre-processing and storage. Industrial carbon is tied to specific emitters and the infrastructure to capture and convert it.

This chapter explains the hub-and-spoke model, how it applies to residues and to waste lipids, what the regional geography suggests, which flagship configurations emerge, and how potential hubs can be assessed. A possible SAF production site cannot be judged in isolation; its viability depends on the supply network behind it. The configurations shown are illustrative, not confirmed sites.



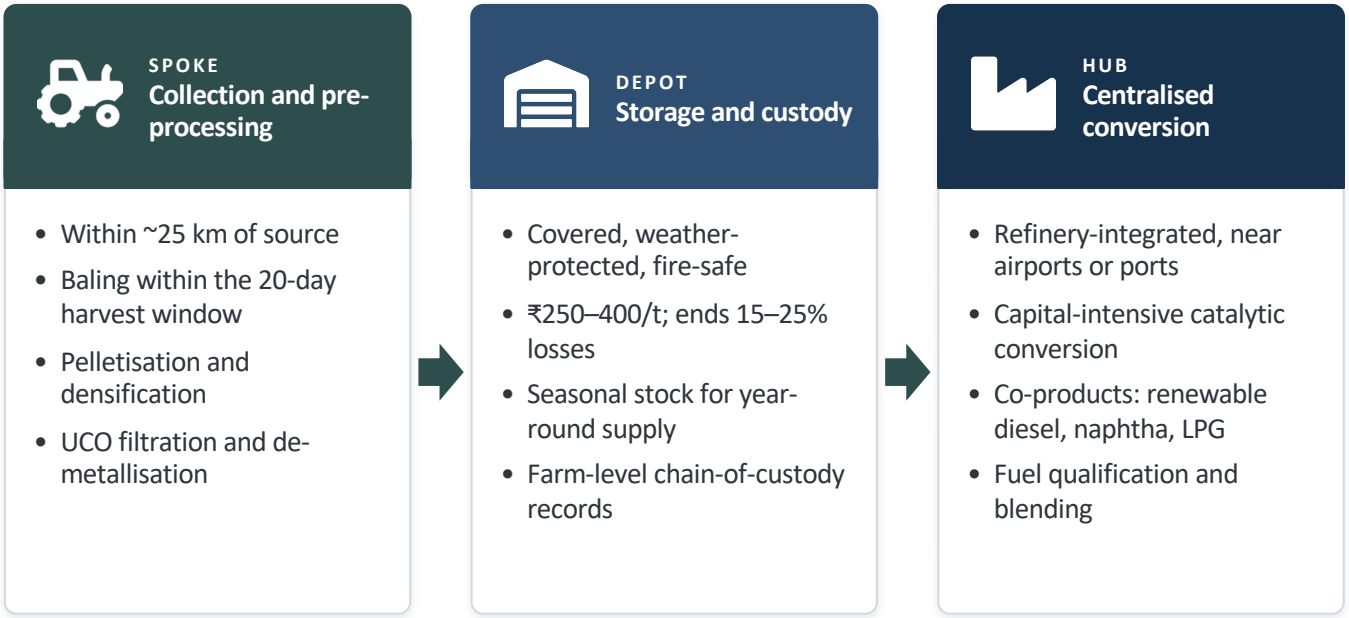
Image: Neste / Airbus

5.1 The spoke-to-hub architecture

Separate local collection and preparation from centralised conversion, so that only prepared, documented material travels.

Feedstocks in Focus: UCO & Biomass

FIGURE 28 **Decentralised spokes, custody depots and centralised conversion hubs**



Source: Ohayo Green Energy hub-and-spoke design, 2026; depot economics from Punjab fieldwork.

For residue-based SAF the difficulty is plain: feedstock is scattered across farms, while a conversion plant needs steady supplies that meet defined specifications. Moving bulky, untreated residue over long distances raises cost and complicates seasonal supply.

Collection and pre-processing spokes. Collection starts close to the source, where residues are gathered and baled and suitable waste oils filtered and de-metallised. Where needed, residues are densified into pellets that are easier to handle and transport. The point is to prepare each material for the next stage without hauling unnecessary bulk.

Storage and custody depots. Regional depots consolidate prepared material and protect it between collection and dispatch. Covered, weather-protected, fire-safe storage limits moisture damage while seasonal stock is built up. Depots also record where material came from and how it moved, the chain of custody that sustainability certification requires.

Centralised conversion hubs. Larger facilities receive prepared feedstock or intermediates and run the capital-intensive conversion and upgrading. Their location should reflect the feedstock catchment, the needs of the pathway and access to industrial and transport infrastructure. Proximity to an airport or port is part of the picture, not a sufficient reason to choose a site.

One architecture, two networks. Residues and waste oils have different collection patterns, handling needs and preparation requirements, so this is not a single standard layout. What both networks must keep is a clear link between the material collected, how it was prepared, its documented movement and its eventual use.

Why it pays. In Punjab, a covered depot costs about ₹250–400 a tonne and recovers, in its first season, storage losses worth ₹90–130 million a season on a 300,000 t baseline. Decentralised pre-treatment also lets catchments go national without a freight-linked carbon penalty on the finished fuel.

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5.2 Regional roles: backbone, corridor and aggregation zone

Overlaying biomass clusters on airports, ports and multimodal transport hubs suggests three broad regional roles.

Feedstock in Focus: Biomass

Uttar Pradesh, Madhya Pradesh, Rajasthan, Punjab and Maharashtra together account for about 360 MMT a year of biomass generation, roughly 47.7% of gross generation (and about 65% of surplus residue), and rice, wheat and sugarcane make up about 53% of the lignocellulosic feedstock considered. These patterns are a starting point; they do not mean all biomass in these states is available for SAF.

Northern India: a potential feedstock backbone. A large agricultural-residue base combined with well-located aviation infrastructure makes the north relevant to chains linking residue-producing areas with processing and fuel distribution. The practical opportunity depends on accessible surplus within workable collection areas, not on gross residue generated.

Western India: processing and multimodal connectivity. Moderate biomass availability with established industrial and port infrastructure makes the west relevant for processing sites and transport links, including an export corridor. Suitability depends on the feedstock catchment, infrastructure needs and access to downstream users.

Central India: a potential aggregation zone. Substantial but dispersed biomass points to local collection and aggregation before material moves to larger plants. The amount and quality of feedstock within an economically workable catchment will decide whether a location suits aggregation, pre-processing or a fuller processing role.

Transport overlay. The analysis overlays biomass clusters on international airports, international ports and multimodal transport hubs. Feedstock regions may serve as collection and aggregation areas, industrial locations as processing and conversion sites, and ports and airports as reference points for moving materials and distributing fuel.

Industrial carbon adds a fourth geography in the longer term: the Odisha, Chhattisgarh, Gujarat and Madhya Pradesh industrial belts, where e-SAF could eventually locate near large CO_2 emitters, if green hydrogen and firm renewable power are available.

FIGURE 29 **Indicative regional roles for feedstock in India**



Source: Ohayo Green Energy regional analysis; Biomass Atlas. Schematic tile map with two-letter state codes (listed under Abbreviations), not to scale and not a boundary map. Roles are indicative, not final plant locations.

OPPORTUNITY BY REGION

Northern districts with residue surplus and weak aggregation are where spoke and depot businesses are most needed; western industrial and port locations suit processing; central India suits aggregation and pre-processing enterprises feeding larger plants.

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5.3 Flagship configurations and where the fuel is used

Hubs need offtake as well as feedstock. Aviation fuel demand is concentrated enough to anchor early configurations.

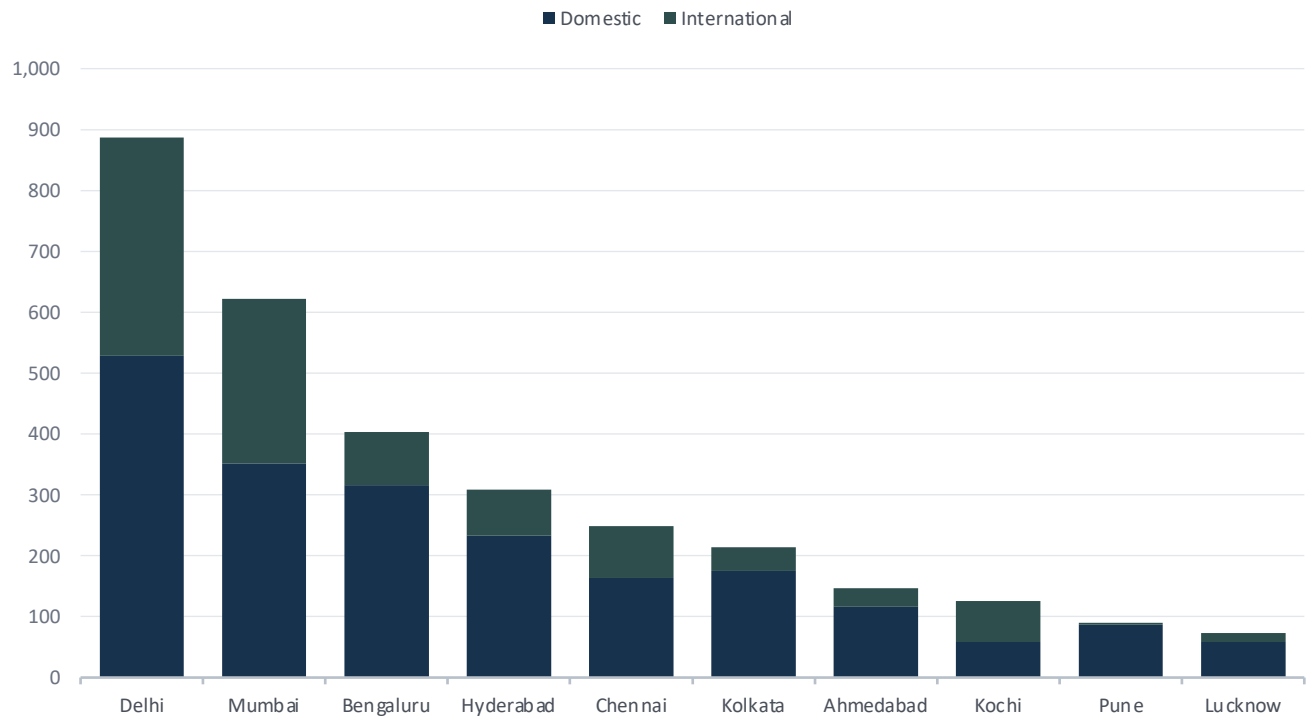
The evidence supports three illustrative flagship hub types. Each would need a defined catchment, accessible feedstock, incumbent uses, preparation and storage arrangements, transport assumptions and the requirements of the receiving pathway before it could be treated as a project.

- **A northern agricultural-residue supply network,** with the Haryana collection model (see 5.4) showing source-level mobilisation feeding refinery-linked conversion in the Punjab–Haryana belt.
- **A western processing and multimodal corridor,** linking residue and lipid catchments with industrial, refining and port logistics in Gujarat and Maharashtra.
- **A central aggregation model** for dispersed biomass in Madhya Pradesh and Chhattisgarh, with spokes and depots feeding larger plants elsewhere.

Refinery-to-airport corridors. The study's logistics analysis indicates that early supply corridors are likely to form between existing refineries and the highest-uplift airports: northern refineries to Delhi and Jewar, Mumbai refineries to Mumbai and Navi Mumbai, and Mangalore to Bengaluru and Hyderabad. Commingled airport hydrants with off-site pre-blending can avoid dedicated SAF tanks, making blending-hub siting, not airport storage, the decisive infrastructure question.

Demand concentration. Delhi and Mumbai account for 16.8% of national ATF, the top eight airports 32.9% and the top 20 40.3%. Kozhikode (78.5% international) and Kochi (53.2%) punch above their passenger weight for CORSIA-linked demand. From 2027 to 2030, production is likely at petroleum refineries, with SAF handling and quality labs at major international airports; standalone biorefineries can follow near feedstock and hydrogen hubs in the 2030s, and smaller airports will need regional blending terminals and road tankers.

FIGURE 30 **ATF uplift at India's ten largest airports, FY2024–25 (thousand tonnes)**



Source: Airports Authority of India traffic statistics FY2024–25 and PPAC, with model-calibrated airport allocations (Ohayo Green Energy demand model).

5.4 Haryana's Crop Residue Management programme

Local collection, shared machinery and digital records can mobilise residue across fragmented holdings. The model is replicable.

FIGURE 31 **From pilot to inter-state rollout**



150,000+ farmers share baling machinery through the Krishiyantra Saathi app; the Meri Fasal Mera Byora platform shows how digital records can support traceability.

Source: Programme's own reporting, as compiled in an Ohayo Green Energy feedstock assessment study. Reported outcomes are not a measure of SAF-eligible feedstock.

What it shows. According to the programme's own reporting, a pilot across six stubble-burning hotspots in Karnal was followed by expansion to 666 villages in nine high-intensity districts, with a 69% reduction in active stubble burning during the pilot and 91% of active fire locations addressed after scale-up. For SAF planning, what matters is how the arrangement operates: localised baling, coordination across villages and shared machinery organise collection across fragmented holdings. Replicating the framework in Uttar Pradesh and Madhya Pradesh would extend that model to two of the five largest biomass states.

Where it could go next. In Uttar Pradesh, the residue base spans sugarcane trash, bagasse and straw, but landholdings are fragmented and farm-waste collection is unorganised, exactly the conditions the Haryana model was built for. Madhya Pradesh, with large but dispersed biomass, fits the central aggregation role in section 5.2.

What it does not show. Turning the model into a dependable SAF chain also needs covered storage, quality controls, documented movement of material and confirmation of surplus after competing uses. It does not prove the same results would follow elsewhere, or that all residue collected would qualify.

A distinct model for waste lipids. UCO and tallow logistics depend less on harvesting and densification and more on collection coverage, material quality, handling and traceability. UCO from many commercial and institutional sources needs an organised network that consolidates oil while keeping records of origin, with filtration and de-metallisation at spokes. Tallow follows rendering. Physical collection does not show that material suits a process or meets certification, so quality control and documentation have to be designed in. A single logistics model should not be assumed to work for both.

Connecting the layers. For residues, aggregation sites are judged on the distribution of sources, collection distances, pre-processing needs, storage capacity and transport links. For waste lipids, they are judged on the reach of collection networks, the location of aggregation and preparation facilities, and the reliability of supply to downstream processors. At the conversion stage, the tests are suitable inputs, the needs of the chosen technology and access to industrial infrastructure, with ports and airports as reference points for the wider movement of materials and fuel.

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5.5 Assessing potential hub configurations

Not every location needs to collect, prepare, convert and distribute on the same site. Assess each by the role it could play.

FIGURE 32 **Roles in a regional hub configuration and the question each raises**

Role	Basis for assessment	Key question
Agricultural-residue collection areas	Concentration and seasonality of suitable residues	What surplus remains after competing uses, and how reliably can it be collected?
Aggregation and pre-processing centres	Access to dispersed sources and preparation infrastructure	Can material be consolidated, prepared and stored economically?
Processing and conversion locations	Access to feedstock or intermediates and industrial infrastructure	Can the facility receive consistent inputs that meet process requirements?
Waste-lipid aggregation networks	Density of collection sources, quality, established channels	Can suitable material be secured with proper handling and traceability?
Multimodal transport connections	Road, rail, port and other transport access	Can feedstock move reliably between supply and processing?
Fuel-distribution interfaces	Link to demand centres and distribution infrastructure	What extra handling, quality and distribution requirements apply?

Source: Ohayo Green Energy hub assessment framework, 2026.

A hub-and-spoke system has to deliver more than volume. It must supply material of suitable quality, at the required time, with enough consistency and documentation to support processing and the applicable sustainability requirements. Three things decide whether it can.

Supply reliability. Collection and aggregation should reflect the quantity that can actually be secured after competing uses and accessibility limits: for residues, seasonal availability, storage performance and losses; for waste lipids, collection coverage, quality and the ability to secure consistent supply.

Quality and preparation. Feedstock must meet the needs of the intended conversion process, and pre-processing should be matched to the material and the receiving plant's specification, not applied uniformly across feedstock types.

Traceability and documentation. Records of origin, handling and movement establish provenance and support eligibility. Aggregating a material does not by itself show that it qualifies for SAF.

Comparing configurations. The framework allows configurations to be compared without assuming one regional model suits every feedstock. How much each criterion matters will vary with the material, the pathway, supply density and the infrastructure available. The regional evidence points to northern India as a potential feedstock backbone, western India as a processing and multimodal corridor and central India as an aggregation zone, but detailed decisions need resource estimates, local supply conditions, competing uses and facility requirements considered together.

A large resource may add little to dependable supply if it cannot be collected consistently, protected in storage, prepared to specification or documented. The effectiveness of a regional hub will depend less on its location or nominal resource base than on how well collection, pre-processing, storage, transport and conversion work together.

OPPORTUNITY

Each role in the table is a distinct business. Entrants do not need to own the whole chain: collection, aggregation and pre-processing, storage and custody, transport and blending can each be built and financed separately, provided the chain of custody connects them.

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6 Conclusion: CORSIA as the baseline

India's SAF opportunity is real. Its scale and timing will be set upstream, by how much suitable feedstock can be mobilised and verified.

Feedstock generation, theoretical potential, accessible surplus and supply that can be delivered to a plant are different stages of availability, each with its own constraints, from existing uses and collection efficiency to storage, transport, processing and traceability. The volume that ultimately reaches SAF production depends on how these interact, not on resource estimates alone.

To 2028, lipids carry the first volumes. UCO and tallow remain the route through proven HEFA, so early blending stands or falls on formal collection, traceability and keeping certified volume in the country rather than on new technology. Access, not abundance, sets the pace.

Through 2030, residue aggregation decides scale. Agricultural residue is the only pool large enough to carry structural volume, and its economics turn on depots, working capital and aggregation, which need to be built over the next few harvest seasons.

Beyond 2030, carbon intensity and cost discipline. Low-carbon hydrogen and power, not the pathway label, will decide compliance value, and every volume ambition still has to clear the 2–2.5x ATF price ceiling the market will bear.

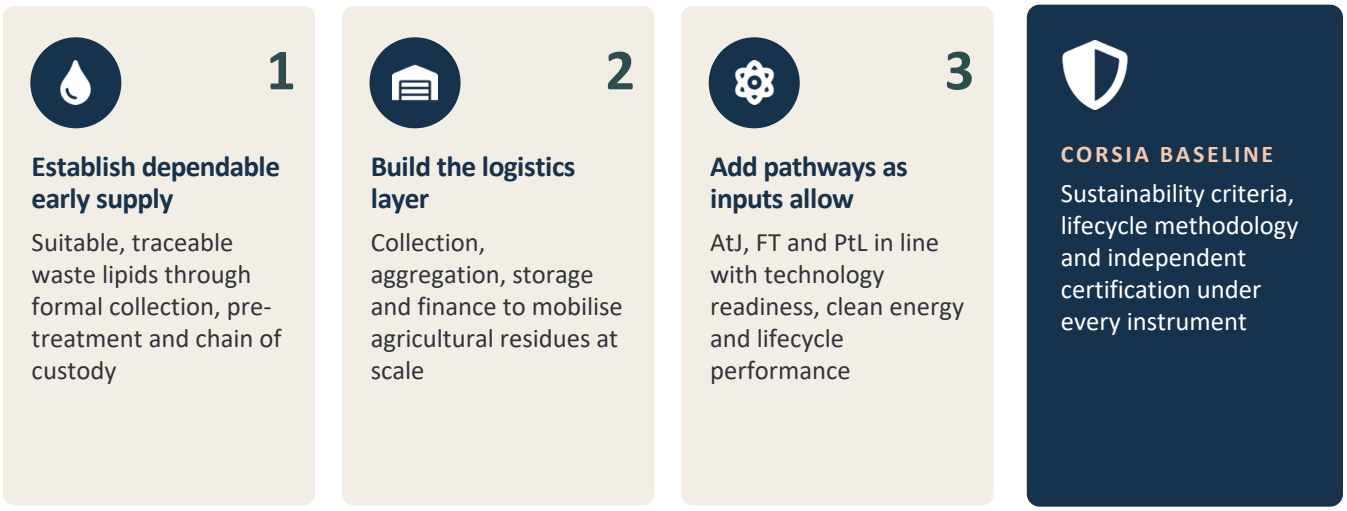
Announced capacity converts only with dependable feedstock and demand. About 0.50 MMT a year is announced, almost all pre-commissioning. Turning it into financed, operating capacity needs secure feedstock contracts as much as plant engineering.



Image: Airbus

6.1 CORSIA as the framework baseline

FIGURE 33 **Three connected requirements, one sustainability baseline**



Sustainability is integral, not a final check. A technically suitable feedstock does not by itself establish that the resulting fuel delivers the expected environmental benefit or satisfies eligibility requirements. Lifecycle emissions depend on the complete chain: feedstock origin, collection and transport, processing, hydrogen and electricity inputs, and conversion efficiency. Fuel produced through the same nominal technology can perform very differently.

CORSIA as the framework baseline. CORSIA should remain the sustainability baseline whatever financial instruments and policy mechanisms national authorities adopt, from blending targets to incentives or lending support. Incentives, targets and financing do not replace evidence of sustainability criteria, lifecycle accounting and independent certification. The baseline is not a claim that every assessed feedstock, modelled pathway or mapped volume is already eligible; technical fuel qualification and destination-market requirements must also be met.

Traceability is the common thread. Documentation of origin, handling and movement establishes provenance where feedstock passes through many collectors, aggregators and processors. Physical availability and environmental eligibility are related, but they are not the same. India-specific lifecycle data, shared verification capacity and chain-of-custody records at spokes and depots are what let Indian feedstock earn its value.

Remaining uncertainties. Feedstock estimates describe different stages of availability; technology-readiness assessments, announced capacities and projections describe different aspects of industry development. The outlook will evolve as projects progress, feedstock markets change, infrastructure develops and sustainability requirements are implemented. Where evidence is incomplete, those uncertainties should stay visible rather than be hidden behind a single headline estimate.

Closing perspective. India's SAF opportunity will be determined by how effectively its feedstock resources, industrial capabilities and supply-chain infrastructure develop together. Expanding one element without the others will not deliver a dependable supply of aviation fuel. The central task is to move from estimates of what India possesses to a clear understanding of what can be mobilised, processed and supplied reliably, under credible commercial and environmental conditions, with CORSIA-aligned sustainability assessment and transparent carbon accounting throughout.

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7 How Ohayo supports SAF scale-up in India

This study took us from national statistics to kitchens, farm gates and refineries. The same depth of evidence is available to any stakeholder building in India's biofuels supply chain.

80–90	10+	7	120+ yrs
stakeholders interviewed for this study	states covered by fieldwork	feedstock groups assessed end to end	combined senior experience in SAF, LCA and energy policy

FOUR WAYS WE SUPPORT THE ECOSYSTEM

Feedstock and supply chains

- Feedstock mapping, from gross resource to mobilisable supply
- Hub-and-spoke aggregation, storage and working-capital design
- Traceability and chain-of-custody set-up

FOR **SAF producers, aggregators, FPOs, CSR programmes**

Project feasibility and bankability

- Pre-feasibility: pathway, hydrogen supply, CORSIA eligibility
- Techno-economic valuation: capex, opex, licensor review
- Financial models for investors and lenders

FOR **Refiners, ethanol and oil producers, investors, lenders**

Carbon intensity and compliance

- Lifecycle assessment localised with Indian supply-chain data
- Hydrogen and power sourcing to stay under CORSIA thresholds
- MRV and carbon-credit project support

FOR **Producers, airlines, corporate SAF buyers**

Ecosystem strategy and capability

- Market, demand and policy analysis for SAF in India
- Intervention and advocacy roadmaps for OEMs and airlines
- Workshops on SAF, LCA and certification

FOR **OEMs, airlines, government, development agencies**

Built on fieldwork. This report rests on interviews across the value chain, from UCO collectors and biomass aggregators in Punjab and Haryana to refiners, airlines and policy makers. Every estimate was tested against what can actually be collected, stored and certified.

Technical Decarbonisation Specialists. Deeply technical projects in challenging areas. Chemicals-to-organics for a large FMCG, new applications for by-products of a biofuels manufacturer and many others.

Proven on Sustainable Aviation Fuel projects. Our team includes former CSIR-IIP leadership that helped enable India's first biofuel-powered flight. Recent SAF work includes a value-chain strategy for a global aircraft manufacturer, a techno-economic valuation for a HEFA SAF plant and a pre-feasibility study for an ethanol producer.

WORK WITH US

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Talk to us about decarbonising hard-to-abate sectors or about feedstock sourcing, project feasibility or carbon accounting for biofuels in India.



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Abbreviations

2G	Second-generation (advanced ethanol from non-food biomass)
AAI	Airports Authority of India
ASTM	ASTM International (formerly American Society for Testing and Materials)
ATF	Aviation turbine fuel
AtJ	Alcohol-to-Jet
BEE	Bureau of Energy Efficiency
BPCL	Bharat Petroleum Corporation Limited
capex	Capital expenditure
CBG	Compressed biogas
CCU / CCUS	Carbon capture and utilisation / and storage
CI	Carbon intensity
CO_2	Carbon dioxide
CO_2e	Carbon dioxide equivalent
CORSIA	Carbon Offsetting and Reduction Scheme for International Aviation
CRM	Crop residue management
CSIR	Council of Scientific and Industrial Research
CSR	Corporate social responsibility
DGCA	Directorate General of Civil Aviation
e-SAF	Electro-SAF (synthetic SAF from power, hydrogen and CO_2)
EU	European Union
FFA	Free fatty acids
FICCI	Federation of Indian Chambers of Commerce and Industry
FPO	Farmer Producer Organisation
FSSAI	Food Safety and Standards Authority of India
FT	Fischer–Tropsch
FY	Financial year
gCO_2e/MJ	Grams of CO_2e per megajoule
GHG	Greenhouse gas
GREET	Greenhouse gases, Regulated Emissions and Energy use in Technologies model
H_2	Hydrogen
ha	Hectare
HEFA	Hydroprocessed esters and fatty acids
HPCL	Hindustan Petroleum Corporation Limited
HVO	Hydrotreated vegetable oil
IATA	International Air Transport Association
ICAO	International Civil Aviation Organization
ICAR	Indian Council of Agricultural Research
IEA	International Energy Agency

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Abbreviations (continued)

IIP	Indian Institute of Petroleum (part of CSIR)
IITs	Indian Institutes of Technology
IOCL	Indian Oil Corporation Limited
IRR	Internal rate of return
ISCC	International Sustainability and Carbon Certification
ISO	International Organization for Standardization
JV	Joint venture
kg	Kilogram
kgCO_2e/kg	Kilograms of CO_2e per kilogram
km	Kilometre
kWh	Kilowatt-hour
LCA	Lifecycle assessment
LPG	Liquefied petroleum gas
Mha	Million hectares
MJ	Megajoule
MMT	Million metric tonnes
MNRE	Ministry of New and Renewable Energy
MoCA	Ministry of Civil Aviation
MoD	Ministry of Defence (United Kingdom)
MoPNG	Ministry of Petroleum and Natural Gas
MP	Madhya Pradesh
MRPL	Mangalore Refinery and Petrochemicals Limited
MRTT	Multi Role Tanker Transport
MRV	Measurement, reporting and verification
MSW	Municipal solid waste
MT	Metric tonne
NABCB	National Accreditation Board for Certification Bodies
NGHM	National Green Hydrogen Mission
NGOs	Non-governmental organisations
NIBE	National Institute of Bio-Energy
NTPC	NTPC Limited (formerly National Thermal Power Corporation)
PAT	Perform, Achieve and Trade scheme
PFAD	Palm fatty acid distillate
PPAC	Petroleum Planning and Analysis Cell
PSU	Public sector undertaking
PtL	Power-to-liquid
RBD	Refined, bleached and deodorised
RED	Renewable Energy Directive (European Union)
ReFuelEU	ReFuelEU Aviation (EU regulation on SAF blending mandates)
RTC	Round-the-clock (power supply)

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Abbreviations (continued)

RUCO	Repurpose Used Cooking Oil (FSSAI initiative)
SAF	Sustainable aviation fuel
SMR	Steam methane reforming
t	Metric tonne
TBO	Tree-borne oil
TRL	Technology readiness level
UCO	Used cooking oil
UK	United Kingdom
UP	Uttar Pradesh
WEF	World Economic Forum

State and union territory codes used on the maps (Figures 8 and 29)

AP	Andhra Pradesh
AR	Arunachal Pradesh
AS	Assam
BR	Bihar
CG	Chhattisgarh
DL	Delhi
GA	Goa
GJ	Gujarat
HP	Himachal Pradesh
HR	Haryana
JH	Jharkhand
JK	Jammu and Kashmir
KA	Karnataka
KL	Kerala
MH	Maharashtra
ML	Meghalaya
MN	Manipur
MP	Madhya Pradesh
MZ	Mizoram
NL	Nagaland
OD	Odisha
PB	Punjab
RJ	Rajasthan
SK	Sikkim
TG	Telangana
TN	Tamil Nadu
TR	Tripura
UK	Uttarakhand
UP	Uttar Pradesh
WB	West Bengal

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Image: Airbus

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