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The Fire We Cannot See

Why India's Sustainable Aviation Fuel strategy is pathway-mismatched to its feedstock — and what the 2028 invoice will cost.

By **Capt. Amit Singh, FRAeS** · Founder, Safety Matters Foundation · Boeing 777 & Airbus A320 Captain · 18,000+ flight hours

Every October, the Indo-Gangetic Plain performs a quiet national arithmetic. Twenty million tonnes of paddy straw are set on fire in Punjab, Haryana and western Uttar Pradesh. The smoke travels south to Delhi. The airshed closes. Schools shut. Hospitals report a spike in respiratory admissions. The Supreme Court admonishes the states. The states admonish the Centre. The Centre commissions a committee. The rabi sowing begins. The smoke clears. The cycle waits for next October.

Eight months from now, on 1 January 2027, a second fire will start — one most Indians will never see. Every Indian international carrier will enter the mandatory phase of the Carbon Offsetting and Reduction Scheme for International Aviation. The offset liability through 2035 is projected at between one and a half and two billion US dollars. Much of that will flow to Brazilian forestry projects, Kenyan cookstove programmes, and direct-air-capture startups in Texas.

These are the same fire. The first one produces the very feedstock that could extinguish the second. And India is currently on course to burn both ends.

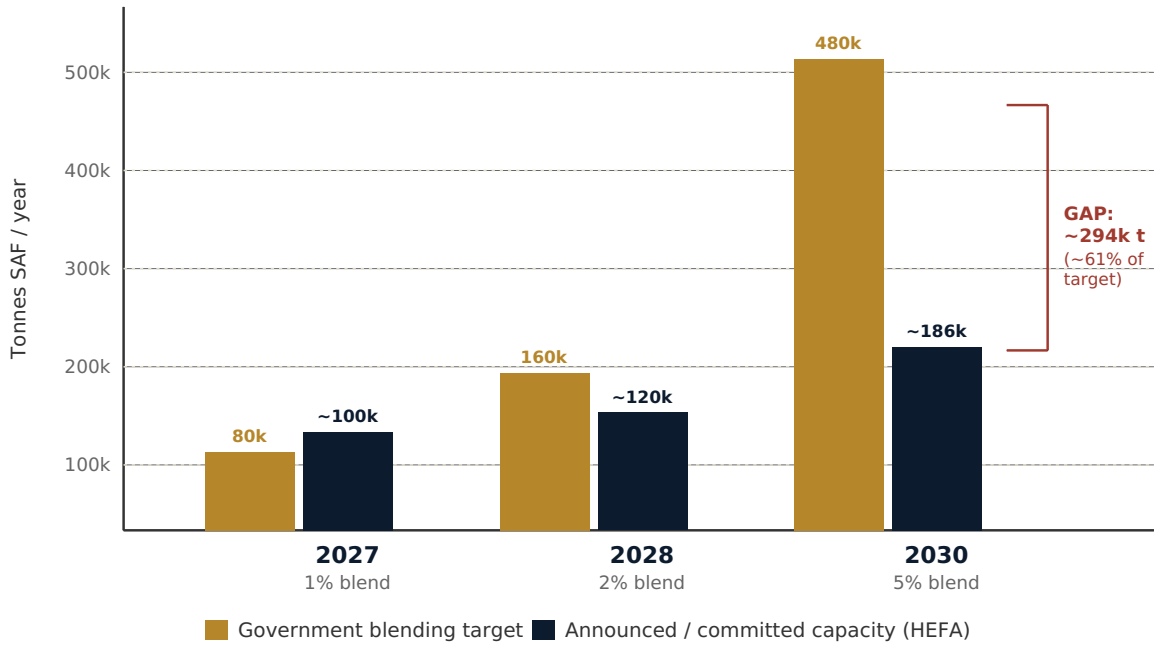
This piece is not about whether Sustainable Aviation Fuel works. It works. It is certified under ASTM D7566, it is chemically indistinguishable from Jet A-1 at the tailpipe, and a Boeing 777 at FL370 cannot tell the difference. This piece is about a narrower and sharper question: of the Indian government's announced SAF capacity build-out, *what share of it uses the feedstock India actually has in abundance?* The answer, as of April 2026, is approximately zero per cent. That is the argument.

The landscape, in one picture

Before the policy critique, the numbers. India's position on SAF is not an absence of activity. The government has announced targets. Indian Oil has commissioned a certified facility. BPCL has committed capital. Airlines have signed offtake agreements. What is missing is the arithmetic between the announced capacity and the target it is meant to meet.

Figure 1 · India's announced SAF capacity against its own blending targets

Tonnes per year, 2027 to 2030. Announced capacity does not meaningfully close the 2030 gap.



Government targets per DGCA/MoCA announcements (1%, 2%, 5% of international aviation fuel demand). Announced capacity figures compiled from IOC Panipat (~30 kt HEFA from 2025; 87 kt ATJ from 2028), BPCL Mumbai/Kochi/Bina commitments (~50 kt), and MRPL Mangalore (~6 kt). All current announcements are HEFA-pathway until 2028, when IOC's LanzaJet ATJ facility is scheduled.

The gap is not marginal. It is roughly three-fifths of the 2030 target. And every announced tonne of Indian SAF capacity through 2027 uses the same feedstock: used cooking oil, processed via the HEFA pathway. This is a specific strategic choice. It is also, at scale, the wrong one.

HEFA and ATJ — the two serious answers, and how they compare

There are eleven ASTM-certified pathways to Sustainable Aviation Fuel. Two of them account for essentially all commercial SAF production through 2030: HEFA (Hydroprocessed Esters and Fatty Acids) and ATJ (Alcohol-to-Jet). Two more — Fischer-Tropsch and Power-to-Liquid — are strategically important but do not operate at commercial scale in aviation fuel anywhere in the world today. A complete answer requires understanding what each one does, and where each one fits in a national strategy.

Figure 2 · SAF production pathways: a like-for-like comparison

The four pathways most relevant to India, scored across the dimensions that matter for a 2027–2040 policy window.

Dimension	HEFA (UCO, animal fat)	ATJ (ethanol from residue)	FT-SPK (gasified biomass)	PtL / e-fuel (H_2 + captured CO_2)
Technology maturity	**Commercial, proven**	**First-of-kind (LanzaJet Georgia, 2025)**	**Pre-commercial for cellulosic biomass**	**Pilot stage, 2035+**
Lifecycle CO_2 reduction vs 89 gCO_2e/MJ baseline	~84% (UCO)	~65–85%	**~85–94%**	**~90–100%**
Feedstock supply in India	**~0.3–0.5 MT/yr (UCO)**	**140–230 MT/yr (residue)**	**140–230 MT/yr (residue)**	Unlimited (if green H_2 scaled)
Capex per tonne/yr capacity	**~₹15–20k**	~₹35–50k	**~₹80–120k**	**~₹150k+**
Price premium vs Jet A-1	2–3×	2.5–4× (declining)	3–5×	**5–8×**
Scalability to 2030 target	**Runs out at ~5% blend**	**Covers 30–35% of demand**	**Covers 30–35% of demand**	**Limited by H_2 supply**
Co-benefits	Diverts waste oil	**Farmer income, air quality, forex, jobs**	**Same as ATJ, higher carbon cut**	Decouples from land use
Energy-sovereignty risk	**Imported UCO required at scale**	**Entirely domestic**	**Entirely domestic**	Depends on H_2 import policy

Values compiled from ICAO CORSIA default lifecycle values (Nov 2025 edition), IEA *Energy Technology Perspectives 2024*, ICAO/EU ACT-SAF India Feasibility Study (2025), and KPMG *Fuelling a cleaner sky* (November 2025). Capex ranges converted at 1 USD = ₹88. "Feedstock supply" uses genuinely surplus residue only. HEFA cost premium narrowing; FT-SPK premium expected to converge with ATJ by 2035 on learning-curve effects.

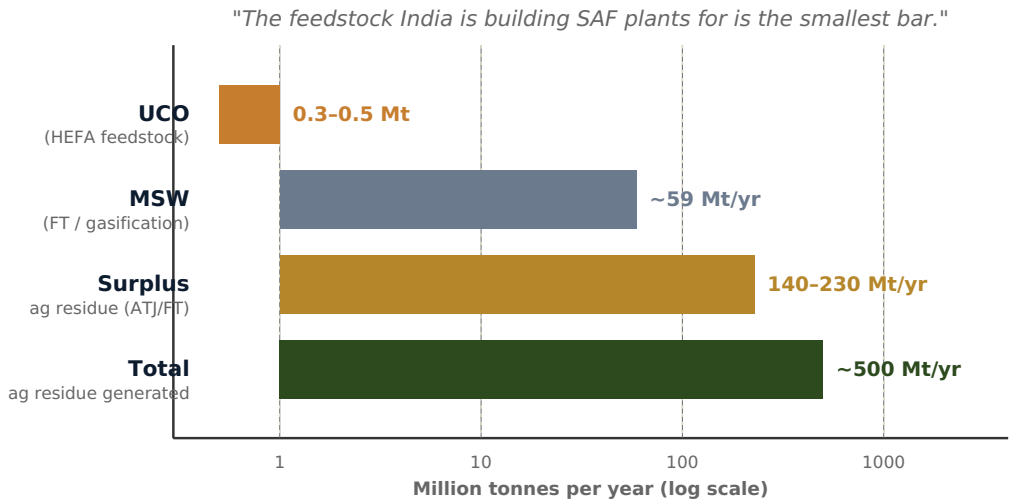
The verdict the table renders is not ambiguous. HEFA is the cheapest and fastest pathway today. It is also the one that runs out of feedstock at the exact blending percentage where India's ambition is supposed to begin. ATJ is technically immature and capital-intensive today. It is also the only pathway that can match the Indian feedstock base to the Indian aviation fuel demand curve over the next twenty years. This is not a minor engineering distinction. It is the central strategic choice that Indian SAF policy must make — and has not made.

The feedstock picture

The scale disparity between UCO and crop residue is best shown visually. The KPMG report published in November 2025 cites 230 million tonnes of surplus agricultural biomass. The ICAO ACT-SAF feasibility study published the same year cites 140 million tonnes using a stricter definition. Either number dwarfs the UCO supply by between two and three orders of magnitude.

Figure 3 · Indian feedstock availability for SAF, by type

Million tonnes per year, genuinely surplus. The log scale is the only way to show all four on one chart.



UCO estimate: MoPNG RUCO programme data, after subtracting biodiesel-committed volumes. MSW: Central Pollution Control Board, 2021, ~59 Mt/yr urban generation. Surplus agricultural residue: ICAO ACT-SAF study (140 Mt) and KPMG November 2025 (230 Mt) — range reflects definitional difference. Total residue generation: National Biomass Atlas, Ministry of New and Renewable Energy.

> *India is building the wrong kind of plant fast and the right kind of plant slow. The cheap, quick win is HEFA, which competes for the same limited used cooking oil already committed to biodiesel. The strategic, scale-matching win is cellulosic, which requires the precise policy intervention the state has declined to make.*

India does not lack capacity. India lacks *pathway* capacity.

The distinction is crucial. In August 2025, Indian Oil's Panipat refinery received India's first ISCC CORSIA certification — the regulatory prerequisite for commercial SAF sales. Commercial production began shortly thereafter, targeting 30,000 tonnes per year of HEFA-pathway SAF from used cooking oil. Air India signed an offtake. The Minister of Civil Aviation announced it as a national milestone. All of this is true.

What is also true: that facility, at full design capacity, produces approximately **six per cent of the 2030 5% blend target**. One facility is not a plan. It is a prototype. And every additional announced Indian facility through 2027 — BPCL's commitments across Mumbai, Kochi, and Bina; MRPL's Mangalore plant — uses the same HEFA pathway on the same constrained UCO feedstock base.

The first cellulosic facility in India, IOC's 86,800-tonne LanzaJet ATJ plant at Panipat, is scheduled for March 2028. That date depends on LanzaJet's first-of-a-kind commercial facility in Georgia, USA, which was itself delayed more than a year and is scheduled to begin operation in the third quarter of 2025. India's entire cellulosic SAF hope through 2028 is anchored to a single US startup's technology that has not yet demonstrated commercial reliability anywhere in the world.

This is not a criticism of Indian Oil. It is state-owned and moving at PSU pace, which is faster than private capital has moved in this space. Reliance has announced nothing. Nayara has announced nothing. Even with IOC and BPCL operating, the aggregate announced Indian capacity sits at approximately one hundred and

eighty thousand tonnes by 2030 — against a requirement of four hundred and eighty thousand. The remaining three hundred thousand tonnes will be imported SAF, imported CORSIA offsets, or an unmet compliance liability.

How India compares internationally

The Indian position is not unique. Every country that has scaled SAF has faced the same capital-market deadlock. Every country that has broken that deadlock has done so through the same three instruments, applied in different combinations: a statutory blending mandate, a price-support mechanism, and a dedicated capital incentive. India has announced the first, as a non-binding target. It has done neither of the others.

Figure 4 · How other jurisdictions unlocked SAF capital

Each country that has scaled SAF used a combination of three instruments. India has implemented none of them with statutory force.

Jurisdiction	Blending mandate	Price-support / tax credit	Capital grant / R&D fund	2030 target
European Union	ReFuelEU: binding, 2% 2025 → 70% 2050	National-level (varies)	Innovation Fund (€40bn+)	6%
United Kingdom	Statutory: 10% 2030 → 22% 2040	Contract-for-Difference (2024 launch)	Advanced Fuels Fund (£180m)	10%
United States	State-level (CA LCFS, OR, WA)	IRA 40B: $1.25–1.75/gallon SAF credit	SAF Grand Challenge (3bn gal by 2030)	~6%*
Japan	10% target (non-statutory)	¥30/L production credit proposed	Green Transition Bonds	10%
Singapore	1% by 2026; levy-funded	Passenger levy on tickets	Sustainable Air Hub Blueprint	3–5%
India	1% by 2027 (indicative, non-binding)	None	None SAF-specific	5% (indicative)

*US target is aspirational under SAF Grand Challenge, not statutory. Colour coding: green = statutory / fully operational; amber = partial or non-binding; red = absent. Sources: ICAO Guidance on Policy Measures for SAF (Oct 2024); KPMG November 2025 report; country government publications.

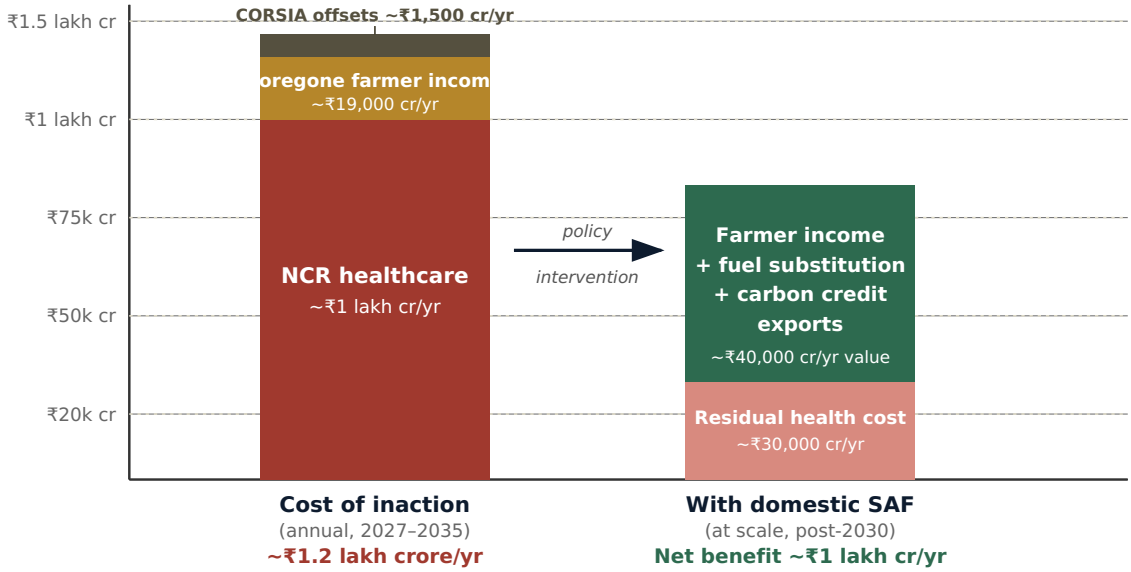
The red row is the argument. India has the feedstock and the ambition of a first-tier jurisdiction. It has the policy infrastructure of a jurisdiction that has not yet decided to act. Every row above it broke the chicken-and-egg deadlock with at least one of the three instruments. India has implemented none of them with statutory force — and is eight months from the CORSIA mandatory phase.

The public health dimension

Aviation policy is usually discussed in the register of carbon and trade. This piece argues that for India specifically, the correct register is also public health. The reason is arithmetic. The twenty million tonnes of paddy straw burned in Punjab and Haryana each October is the single largest source of particulate matter in the National Capital Region during the burn window — and the NCR airshed contains some thirty million people whose respiratory systems bear the cost.

Figure 5 · The four-column bill India already pays

Annual cost categories, 2027–2035, stacked against the cost avoided by a domestic cellulosic SAF industry. Order-of-magnitude estimates, ₹ crore per year.



NCR healthcare cost: central estimate from Lancet Planetary Health / Air Quality Life Index studies on PM2.5 exposure in the Indo-Gangetic Plain during the burn window. Foregone farmer income: 160 Mt surplus residue × ₹1,200/t average net payment. CORSIA offsets: cumulative liability through 2035 annualised. Residual cost estimates assume ~70% residue diversion to cellulosic SAF. All figures are order-of-magnitude; the argument does not depend on precision within a factor of two.

The stack is not a model of precision. It is a model of direction. The burden of *not* acting falls into four separate budgets across four separate ministries — aviation (offsets), health (NCR healthcare), agriculture (foregone farmer income), and petroleum (imported fuel). No single minister sees the aggregate. The burden of acting would fall on a single coordinating decision — a blending mandate with price support. That is the asymmetry at the heart of the policy paralysis.

The hydrogen question

Any complete analysis must address hydrogen-fuelled aviation, because it is frequently cited as the longer-term decarbonisation pathway that might displace SAF. The answer here requires care. Hydrogen aviation is real, it is being developed by Airbus under the ZEROe programme with entry into service targeted for the mid-2030s, and it will eventually play a role. It is also, for the CORSIA-era question this piece addresses, the wrong conversation.

Why hydrogen is not a 2027–2040 answer

Hydrogen aircraft require an entirely new airframe, new engines, new fuel storage (cryogenic tanks take four times the volume of Jet A-1 for equivalent energy), new airport infrastructure (liquid hydrogen supply and handling at every gate), and new regulatory certification. The Airbus ZEROe programme targets short-haul entry into service in the 2035 window, with realistic fleet penetration perhaps 2045 onwards. Long-haul hydrogen aviation is not in any credible industry roadmap before 2050.

For the 2027 CORSIA mandatory phase, hydrogen is irrelevant. For the 2030 blending target, hydrogen is irrelevant. For a first-generation Indian intervention to hit the 2030 five per cent mark, the only technologies on the table are SAF pathways — HEFA, ATJ, and FT-SPK. Hydrogen enters the picture in the 2040s, perhaps,

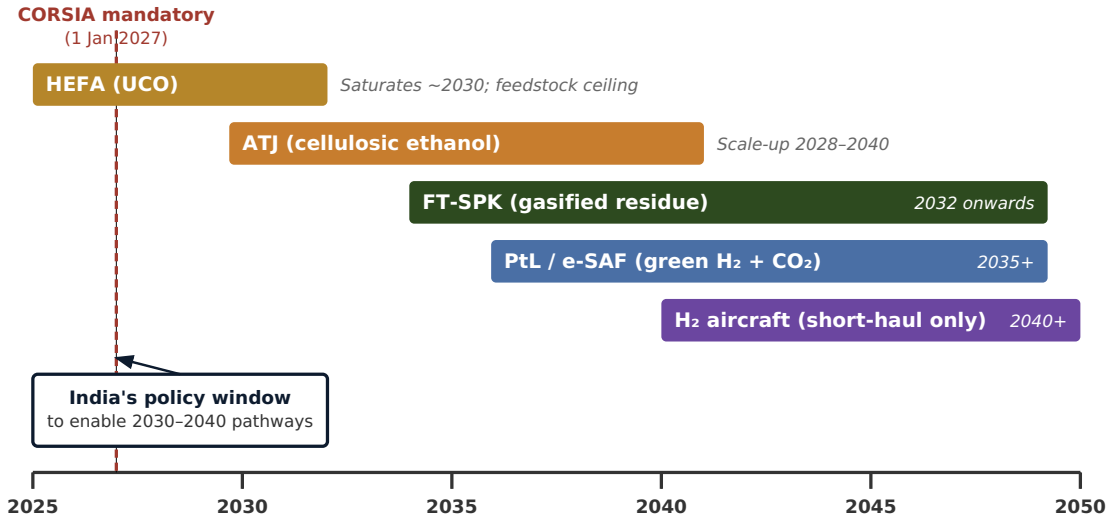
for domestic short-haul. It does not displace the decision India must take this fiscal year.

What the hydrogen question correctly reveals

Where the hydrogen conversation is useful is on Power-to-Liquid (PtL) SAF — e-fuels synthesised from green hydrogen and captured CO_2. These are fully drop-in, meet the ASTM D7566 specification, and at the theoretical limit can deliver near-100% lifecycle carbon reduction. They are also expensive (currently 5–8× Jet A-1), energy-intensive (PtL production requires about four times the green electricity input per litre of fuel), and in pilot stage globally. Germany has taken the lead with 24 of 28 national SAF projects focused on PtL. India has taken no position. The National Green Hydrogen Mission's five million tonnes of green hydrogen by 2030, if realised, could in principle underwrite a meaningful PtL SAF industry — but that linkage is entirely unmade in current Indian policy.

Figure 6 · Decarbonisation pathways by time horizon

Each pathway has a window when it is the correct answer. The windows do not overlap neatly, but they are visible five years ahead of need.



Bar length indicates commercial scale-up window, not endpoint. HEFA is operational now but saturates by around 2030 due to feedstock ceiling. ATJ scales through the 2030s contingent on 2G ethanol maturation. FT-SPK is pre-commercial for biomass globally. PtL and hydrogen aviation are 2040s technologies that require different infrastructure bets. The India policy window to enable the 2030–2040 pathways closes well before the pathways themselves open.

What India should actually be doing

The specific shape of India's policy absence can be described in five items, each of which has a counterpart in jurisdictions that have succeeded, and each of which requires a coordinating decision rather than new legislation. Four of these appeared in my earlier writing on this topic. The fifth has emerged from the Indian Oil–LanzaJet dependency that became visible only in the past nine months.

Figure 7 · Five instruments India has not deployed

None of these require new legislation. All of them have been implemented successfully in comparable jurisdictions.

#	Instrument	What it does	International precedent	Implementing ministry
1	**Statutory blending mandate**	Converts the indicative 1%/2%/5% targets into binding compliance under the Aircraft Act. Non-compliance penalties calibrated to CORSIA offset price.	ReFuelEU (EU), UK SAF Mandate	MoCA + DGCA
2	**Contract-for-Difference price support**	Reverse auction; refiners bid lowest 15-yr SAF price; Centre underwrites delta against spot Jet A-1. Transfers price risk from refiner to state.	UK (2024 launch)	MoPNG
3	**Cellulosic SAF viability gap fund**	₹10,000 cr over 5 years. Competitive awards for integrated residue-to-SAF facilities. Criteria include FPO offtake contracts and domestic tech content.	US IRA 40B; Japan Green Transition Bonds	MoPNG + MoA
4	**Aviation-specific carbon credit registry**	Domestic CORSIA-eligible credit supply rooted in Indian agricultural and forestry projects. Retains offset revenue within the country.	Brazil's RenovaBio	MoEFCC + MoCA
5	**Technology-transfer risk underwriting**	Insurance mechanism for first-of-kind facilities dependent on overseas technology providers. Reduces capex risk on LanzaJet-dependent and FT-dependent plants.	UK Advanced Fuels Fund (£180m)	Department of Economic Affairs

Each of these can be announced in a Union Budget. None require Parliamentary approval. The viability gap fund figure is comparable to the SATAT programme for compressed biogas. All five have been recommended in whole or part by the ICAO ACT-SAF Feasibility Study (2025) and the KPMG *Fuelling a cleaner sky* (Nov 2025) reports commissioned or received by the Indian government.

The rarest kind of policy opportunity

In most climate policy debates, the trade-offs are genuine. Abatement costs money. Cleaner fuel costs more than dirtier fuel. Rural incomes rise only if urban subsidies fall. Someone pays, someone receives, and the political economy of who pays and who receives determines whether the policy is politically viable.

Stubble-to-SAF is the rarest of exceptions. It is a policy intervention that pays farmers, abates carbon, substitutes imported fuel, improves urban air quality, generates export-eligible carbon credits, and builds strategic industrial capacity in a sector where India today is a fuel importer. The intervention aligns the interests of Punjab smallholders, Indian refiners, Indian airlines, the National Capital Region's public health, the Ministry of Finance's foreign exchange position, and India's obligations under the Paris Agreement.

The number of Indian policy interventions that achieve even three of those objectives simultaneously is small. One that achieves all six is, as far as I am aware, unique.

The fact that this opportunity has not been seized is not a failure of any particular individual. It is a failure of institutional coordination of exactly the kind that the central government exists to solve. When the Ministries of Civil Aviation, Petroleum, Agriculture and Environment must each sign off on a scheme, and no single Secretary holds the pen, no scheme gets written. The ethanol blending programme was rescued from this fate in 2018 by the elevation of E20 to a direct prime ministerial commitment, which created a coordinating authority above the individual ministries. The stubble-to-SAF intervention requires the same institutional

escalation. Without it, we will continue to watch four separate ministries optimise four separate spreadsheets, and the aggregate outcome — the one the country actually lives with — will continue to be an October sky full of smoke and a January 2028 invoice paid in US dollars.

What the ICAO feasibility study concluded, in its own words

The ICAO ACT-SAF Feasibility Study for India (2025), co-authored by Susan van Dyk and Ajay Deshpande and commissioned by ICAO with EU funding in cooperation with the Republic of India, concluded that India "has enormous potential for establishing a substantial domestic SAF industry to supply its own needs as well as having excess SAF available for export" — with a 14 to 33 million tonnes per year potential, sufficient for up to 70% SAF blends. The same study's Section 4.1 Recommendation 1 called for the establishment of "a SAF Council representing stakeholders... with decision-making power." As of April 2026, that council has not been established. The document was formally delivered to DGCA via its appointed focal point. The arguments in this opinion piece are not novel. They are the arguments the government has already been told.

> *The question is not what to do. The question is when. And the cost of the answer "later" is already being counted, in the smoke over Delhi, in the foreign exchange reserves of the Reserve Bank of India, and in the fields of Punjab, where the feedstock is once again being prepared for burning this October.*

The closing argument

The seat-back safety card on every aircraft instructs passengers that, in the event of a loss of cabin pressure, oxygen masks will drop from the overhead panel. The standard instruction is that a passenger must secure their own mask before assisting others. The logic is not selfishness. It is that a person who cannot breathe cannot help anyone else breathe either.

India's aviation policy is currently reaching for the overhead panel. CORSIA is the cabin descending through ten thousand feet. The mask is there. The oxygen is there. The feedstock is in the fields. The refineries are standing ready to be upgraded. What is missing is the last mechanical step — the hand that pulls the mask down and secures it.

That step is, in the Indian institutional context, a single coordinating decision from the Prime Minister's Office, authorising the Ministry of Civil Aviation to issue a statutory blending mandate under the Aircraft Act, backed by a Contract-for-Difference price-support mechanism administered by the Ministry of Petroleum and Natural Gas, and a viability gap fund for cellulosic SAF administered jointly with the Ministry of Agriculture. None of these require new legislation. All of them require the coordination of existing instruments.

The policy architecture is not missing. The decision is.

Until it is taken, every October will produce the same smoke, and every January will produce a larger offset invoice, and every year that passes makes the infrastructure India must eventually build more expensive and more urgent. The opportunity does not wait. The fields will burn again in October 2026. The CORSIA phase will begin in January 2027. The first compliance invoice will land in January 2028.

We are building the wrong kind of plant fast and the right kind of plant slow. We are paying for air quality in hospital bills and for carbon in forex reserves, when we could be paying farmers and saving both. We are

treating as separate four problems that are, in their economic substance, one problem.

The fire we cannot see is the more expensive one. It is the fire of institutional inaction — the fire that burns, slowly, at the base of every policy paralysis that leaves a national opportunity uncollected. That fire has been burning for at least five years, since the original CORSIA reservation was filed. It is burning hotter now, because the deadline is closer. And unless the coordinating decision is taken in the coming months, it will continue to burn through 2027, 2028 and every year after, at the rate of approximately one and a quarter lakh crore rupees of avoidable cost per decade.

That is a very expensive fire. And it is, unlike the one over Delhi, entirely inside the government's capacity to extinguish.

Capt. Amit Singh, FRAeS, is a Boeing 777 and Airbus A320 captain with over 18,000 flight hours. He is the founder of Safety Matters Foundation (safetymatters.co.in), hosts the mindFly Katha podcast, and writes on aviation safety, human factors and regulatory policy. Views expressed are personal and do not represent any employer or institution.

Primary sources consulted: ICAO ACT-SAF Feasibility Study for India (van Dyk & Deshpande, 2025); KPMG India *Fuelling a cleaner sky: India's opportunity in sustainable aviation fuel* (November 2025); DGCA India CORSIA Seminar Presentation; Lok Sabha Unstarred Question No. 4012 (12 December 2019); Argus Media coverage of IOC Panipat ISCC certification (21 August 2025); IATA *Net Zero Progress Report 2024* and CORSIA Fact Sheet (December 2025); ASTM D7566 and D1655 specifications; ICAO Default Life Cycle Emissions Values for CORSIA Eligible Fuels (November 2025); FAO Environment and Natural Resources Management Working Paper No. 95 on Punjab rice straw (2022); National Biomass Atlas, Ministry of New and Renewable Energy; Central Pollution Control Board data on MSW generation; ICAO Guidance on Policy Measures for SAF (October 2024).

Notes on figures: All order-of-magnitude estimates in Figures 1, 3, 5, and 6 are compiled from the primary sources above. The precise numbers should not be relied upon without independent verification, but the orders of magnitude are robust to the methodological differences between the underlying studies. The author welcomes corrections and tighter estimates from specialist readers.