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Cleared for a Green Take Off: India–EU Pathways for a Sustainable Aviation Fuel Future

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Title

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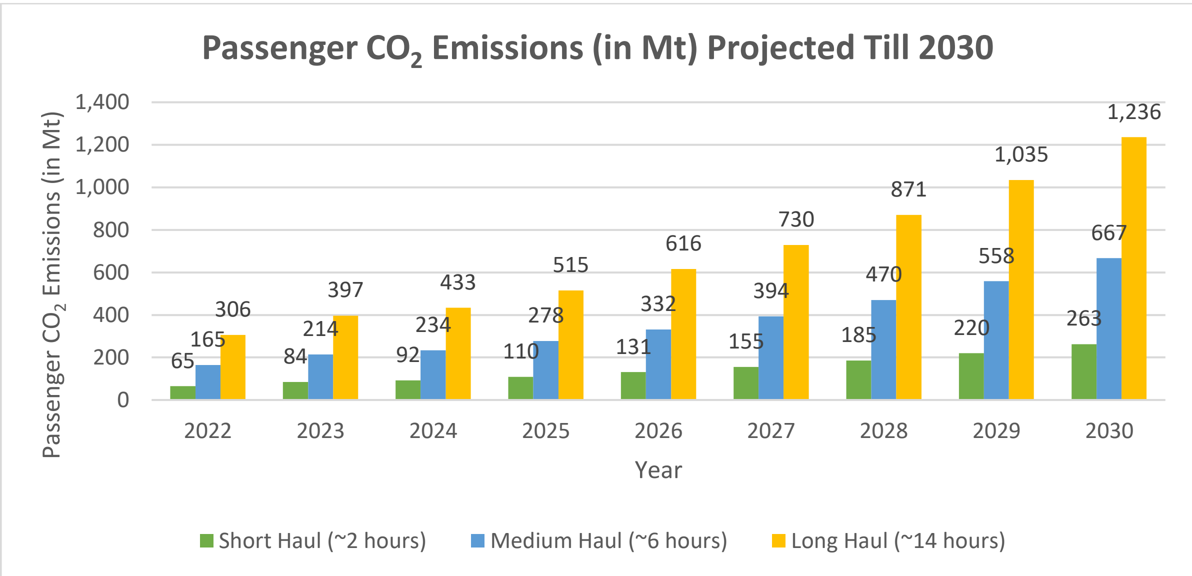
Aviation Emissions and the Urgency of Decarbonization

In 2023, global aviation carried over 8.7 billion passengers, with revenue passenger-kilometers (RPK) rising 94% to nearly 8.1 trillion RPKs. (ACI & ICAO, 2025). The largest passenger markets, were the United States of America, China, India, and Spain. Within this global picture, in 2024, India's civil aviation sector catered to 285.3 million air passengers, including 220.8 million domestic travellers, marking it as one of the world's fastest growing aviation markets in the world (PIB, 2025). The Indian air cargo industry handled a significant amount of 3.7 Mt of load in 2024 (Kurian, 2025). In 2023, India's aviation sector emitted around 25-30 Mt of CO_2 equivalent which is expected to rise rapidly due to the addition of more airports with international connectivity (Santhanam, 2024). In the European Union, the sector emitted approximately 187.6 Mt of CO_2 (Khan, 2025). This represents close to 4% of the overall EU greenhouse gas (GHG) emissions and stands the second-largest origin of mobility sector emissions after automobiles (EAFO, 2024).

Figure **1** highlights the concerning increase in aviation passenger CO_2 emissions across short, medium, and long-haul air routes in the world, underscoring the low-carbon transition hurdle that looms.

Figure 1: Passenger CO_2 Emissions (in Mt) Projected Till 2030



[1]Source: Airports Council International and International Civil Aviation Organization

This indicates a pressing need to transform the aviation sector which will not only mitigate its environmental footprint but also ensure the sector's long-term viability in a world shifting towards low-emission mobility. To alter this trajectory, Sustainable Aviation Fuel (SAF) can offer a short-term, high-impact pathway. Industry leaders regard SAF as the definitive solution for its drop-in compatibility and its potential of cutting carbon emissions by up to 80% (Airbus, 2025). However, there is an uncomfortable truth below this optimistic approach where bio-based SAF alone cannot power the scale of demand hurtling

[1]Assumptions: CAGR from 2024 to 2030 calculated as 19%.
Short Haul Route: Delhi-Bengaluru | Medium Haul Route: Delhi-Jeddah | Long Haul Route: Delhi-New York

toward us. Raw material constraints, land competition, and overlapping industrial requirements suggest that today's SAF trajectory can stall before it ever takes off.

Green hydrogen is an often-overlooked driving force in the SAF conversation. It is produced from Renewable Energy (RE) and can synthesize high grade hydrocarbons when combined with captured CO_2. As a result, it turns SAF from a limited decarbonization tool into a truly large-scale aviation pathway. It does not just supplement bio-based fuels, it unlocks the Power-to-Liquid (PtL) pathway that can supply ample amount of jet fuel without the agricultural trade-offs of biofuels, including competition with food production and cyclical feedstock constraints.

For both India and the EU, this hydrogen-SAF nexus shows more than a choice of technology. It depicts the market's strategic alignment, renewable potential, and industrial capability. Till now, this convergence exists more on paper than in practice. Policies treat SAF and hydrogen as parallel topics, investments hardly bridge the gap, and cross-border cooperation remains uncertain.

Contextualizing Green Hydrogen in Sustainable Aviation Fuel

SAF is often categorised into two broad classes: first, biomass-derived fuels produced from waste oils, agricultural residues, or municipal solid waste, and second, synthetic fuels made through the PtL route. The latter uses green hydrogen, made from RE powered electrolysis and concentrated CO_2 for biogenic or Direct Air Capture (DAC) sources to produce drop-in jet fuel. While both these routes reduce emissions relative to conventional jet fuel, PtL provides the capacity and reliability that bio-feedstocks cannot match.

The EU has already formally recognised this opportunity within its policy framework. Under ReFuelEU Aviation, blending mandates start at 2% SAF in 2025 and is said to go on up to 70% by 2050, with a designated goal for synthetic fuels beginning at 1.2% in 2030 (EUASA, 2025). This certain approach of hydrogen-based SAF not only enhances a steady demand signal but also an incentive for technology developers to optimize PtL processes. This is also coupled with funding mechanism like the Horizon Europe and the Innovation Fund, the EU has developed a policy-finance ecosystem that provides green hydrogen production and SAF certification pathways.

In contrast, India is still at a very nascent stage. Pilot flights using biojet fuel have shown technical feasibility, but as of now there is a lack of blending mandate. In addition, there is no national SAF strategy, and no targeted policy linking green hydrogen to aviation. The National Green Hydrogen Mission sets an ambitious production target of 5 million metric tonnes (MMT) per year by 2030 (MNRE, 2023), but its focus is largely on industrial decarbonisation, steel fertilizers and heavy transport while aviation remains absent from its priority list. Yet India's vast agricultural residue base offers abundant biogenic CO_2 for PtL synthesis, and its high solar potential makes large-scale green hydrogen production economically promising.

The EU's structured policy environment and India's latent feedstock and RE advantages can create a unique chance to co-create a cross-regional hydrogen-SAF value chain. The EU's early regulatory push can anchor the demand, while India's cost-competitive production can expand global supply. The difficulty is in merging these capabilities by means of synchronized benchmarks, co-financed infrastructure, and coordinated technology deployment.

Technological Promise and Untapped Synergy

Green hydrogen's purpose in SAF serves not just as an input, but as a catalyst. This allows large-scale decarbonisation of aviation to happen. Through the PtL channel, hydrogen's purity and energy density convert directly into good fuel quality, whereas its clean source ensures deep lifecycle emission cuts when matched with captured CO_2. Unlike bio-based SAF, which is curtailed by seasonal feedstock flows and land competition, hydrogen-based SAF is limited mainly by RE capacity and CO_2 availability, both of which can be grown through infrastructure financing and technological advancement.

India's technological superiority lies in its capability to produce inexpensive RE, particularly solar. Additionally, India's vast agricultural and biomass processing sector produces significant amount of biogenic CO_2, a critical ingredient for PtL SAF that can be harnessed and used with lower energy penalties than DAC.

The EU benefit is in mature electrolyzer production, meticulous engineering for PtL reactors, and decades of expertise in aviation fuel accreditation. The EU research initiatives have already piloted modular hydrogen-to-SAF units, which could be replicated for growth market scenarios. Furthermore, the airports in the EU are experimenting with hydrogen hubs, positioning them as early pilot sites for on-site PtL SAF production.

Combined these strengths open three underexplored partnerships. First, the circular industrial integration where excess heat and oxygen from electrolysis in India can be fed into nearby industrial clusters. This could enhance the system efficiency, thereby reducing hydrogen costs. Second, is the utilisation of biogenic CO_2 for PtL enabling the linkage to India's agri-waste plants with the EU PtL facilities. This can create a stable CO_2 supply chain for SAF production, reducing dependency on high-cost DAC. Third, is the development of airport hydrogen microgrids where joint India-EU pilots at major hubs can show co-located RE generation, electrolysis, and PtL SAF synthesis. This points out that neither India's resource base nor the EU's technological expertise individually can fully unlock the hydrogen-SAF potential. But together, they have the potential to move beyond pilot projects to create a commercially viable and relevant supply chain.

India's Policy Gaps and Hidden Constraints

India's aviation emission abatement narrative has been characterised by favourable test runs but there is an absence in strong strategies. The policy discourse is yet to integrate that hydrogen-based SAF is not just an option, it is the only way which is capable of expanding in parallel with India's aviation growth without encountering structural supply constraints.

This policy gap mainly has three interlinked problems. Firstly, hydrogen-ready airport installations right now do not exist in India. While airports are increasing day by day to manage passenger growth, hydrogen readiness is not a part of terminal or fuelling infrastructure planning. Second, legal faults exist in synthetic fuel certification. The unavailability of domestic PtL SAF standards aligned with international aviation requirements pressurises producers to depend on foreign accreditation, slowing the commercial beginning and rising the compliance costs. Finally, funding is still a major a bottleneck in the absence of binding purchase commitments from airlines or public agencies, hindering the private investment, unlike in the EU, where such guarantees make room for demand stability.

A cohesive hydrogen-SAF policy framework would not only resolve these systematic shortcomings but place India as a cost-competitive global hub for next-generation aviation fuels.

The EU's Leadership and Limitations

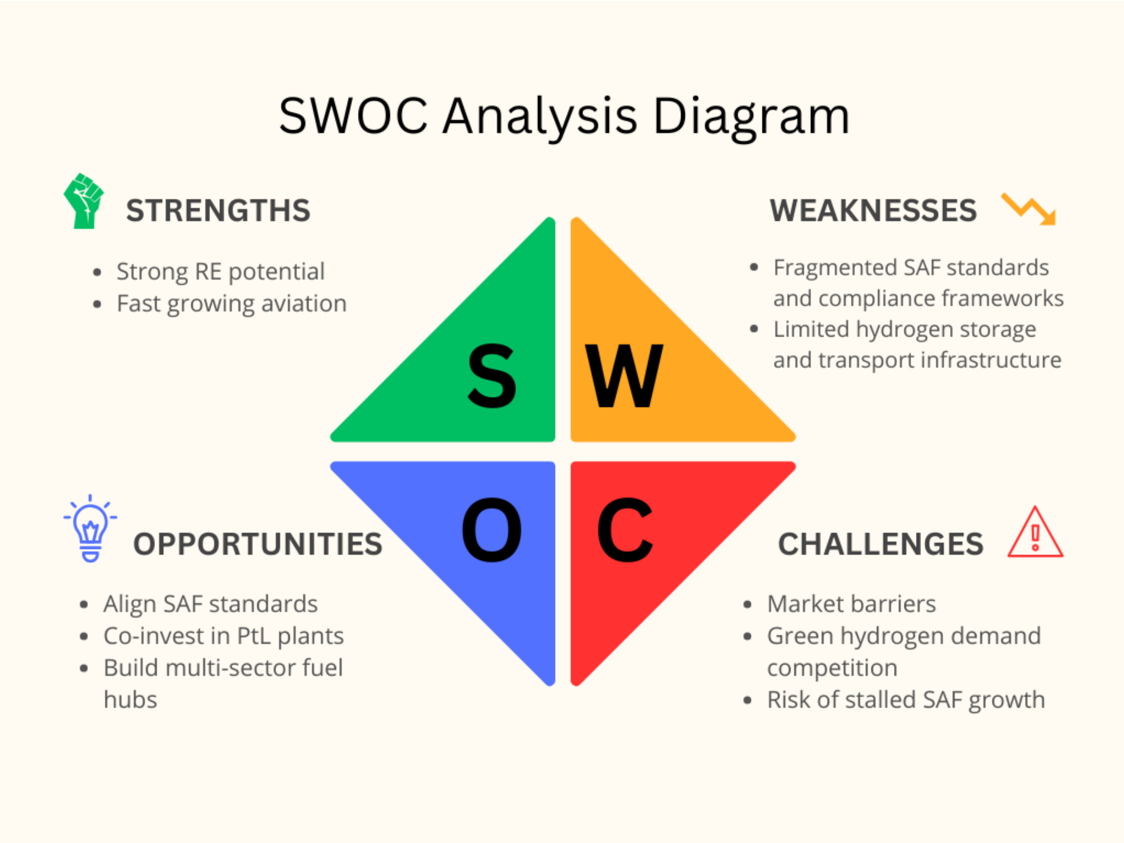
The EU has positioned itself as a frontrunner region in linking green hydrogen and SAF through a strong system of roadmaps, financing tools, and governance frameworks. The European Green Deal and the EU Hydrogen Strategy has led to long term regulatory stability for rollout of green hydrogen. Carbon contracts for difference, innovation funds, and emissions trading revenues, place Europe as one of those few regions where SAF developers can trust on multi-tiered advantages.

Yet these strengths hide systematic weaknesses. The EU's RE costs remain among the highest in the world, diminishing the market strength of domestic PtL production. Grid congestion and long licensing for wind and solar projects curb the buildout of the RE capacity needed to produce hydrogen at a very large scale.

Furthermore, the differences in lifecycle emissions accounting, certification procedures, and hydrogen specification thresholds across jurisdictions cause problems for global SAF trade.

SWOC Analysis: India-EU Hydrogen-SAF Collaboration

Figure 2: SWOC Analysis for India-EU Hydrogen-SAF Collaboration



The emerging India-EU ecosystem for green hydrogen in SAF relies on mixed strengths. The EU has a mature policy framework, diversified financial instruments, and advanced PtL pilots, while India contributes to low-cost RE potential, more than enough of agricultural waste for producing biogenic CO_2 and of the fastest growing aviation markets.

However, there are weaknesses too. India is short of binding SAF blending mandates, which escalates to a confusion among the financiers without clear investment hints. The EU faces high RE based power prices and very slow approvals, elevating the cost of domestic PtL production. So, both the regions face issues because of fragmented compliances, poor frameworks and limited hydrogen storage and transport infrastructure.

However, there are chances too. Correlating SAF-hydrogen sustainability standards could open a new gateway for mutual accreditation schemes. This can make fuels produced in India to meet the demand of the EU. Co-investment in Indian PtL plants leveraging EU finance and technology with shipping fuel markets could create multi-sector market centres, lowering production costs.

Yet significant risks are also there which cannot be ignored. Market shielding could impact technology transfer or supply chains. Global market competes for green hydrogen particularly from steel and ammonia sectors may take away the resources from aviation. Without early action to tackle these risks, the hydrogen-SAF opportunity can narrow down before even getting materialised.

Unique Barriers to India-EU Hydrogen-SAF Collaboration

The real barriers to an India-EU hydrogen-SAF value chain lie deeper in systematic blind spots that have received far less attention.

First is the standards imbalance pitfall. While both India and the EU are creating SAF and hydrogen validation frameworks, their sustainability criteria and greenhouse gas accounting approaches vary.

Second is the mismatch in latent infrastructure geography. India's RE expansion is largely inland and distant from airport or potential PtL hubs, whereas the EU's hydrogen-ready ports and industrial clusters are very rarely located with aviation fuel distribution clusters. Coordinating infrastructure siting across such different geographies is a logistical challenge that neither side has yet factored into jointing planning.

Third is the carbon source paradox. For PtL SAF, biogenic CO_2 is as critical as green hydrogen. India's industrial CO_2 streams are often too diluted for direct PtL use, while the EU's biogenic CO_2 potential is constrained by limited biomass availability. This creates a joint dependency on advancing high-purity CO_2 capture technologies, an R&D area still in its infancy in India and underfunded in the EU for aviation-specific applications.

Finally, the diplomatic bandwidth gap. India-EU energy cooperation has historically prioritised solar, wind, and grid integration, leaving hydrogen-SAF integration without a dedicated negotiation track. This absence of a formal policy delays decision-making, dilutes accountability, and leaves industry-led initiatives without government backing when navigating export regulations or IP transfer hurdles.

Recommendations for Unlocking the India-EU Hydrogen-SAF Nexus

Tackling the hidden obstacles in the India-EU hydrogen-SAF supply chain demands more than policy alignment on paper. A forward-looking reconfiguration of the framework is needed. One way forward is the establishment of a joint SAF-hydrogen standards testbed, where India and the EU jointly create and test provisional certification frameworks before deciding on the final regulatory regimes. Such a sandbox would provide pilot projects to thrive under mutually recognised criteria for greenhouse gas accounting, sustainability benchmarks, and fuel traceability, avoiding costly retrofits. Infrastructure planning must also progress past incremental upgrades toward dual-network hubs, well-positioned sites that combine generation, high-purity CO_2 capture, and SAF distribution. In India, these hubs could be positioned in resource abundant states with proximity to airports, while in the EU they could utilise hydrogen-ready ports aligned with major aviation corridors.

The carbon source paradox can be tackled by establishing a transnational carbon source exchange platform that connects biogenic CO_2 producers, industrial emitters, and PtL developers across both regions, supported by targeted R&D funding for separation technologies optimised for SAF applications. A dedicated track within the India-EU Trade and Technology Council would institutionalise cooperation, provide a venue for negotiating intellectual property frameworks, coordinate joint funding calls, and streamline export licensing for PtL-related components.

Finally, EU SAF mandates surge from 2035 while India's hydrogen targets end in 2030 without aviation specific goals, requiring aligned demand-supply timelines. This would entail a joint long-term forecast to 2050, with interim SAF blending targets for India to match the EU demand. Such coordination would allow early purchase contracts, reduce investor uncertainty and lock in supply chains prior to mandate deadlines. By addressing not only the obvious constraints but also the deep-seated systematic misalignments, these measures could transform the India-EU hydrogen-SAF partnership into a globally competitive decarbonisation engine.

The Bottomline

India-EU hydrogen-SAF stands at an inflection point. The choice is not between acting or waiting, it is between co-designing a shared future now or inheriting a fragmented system later. The runway is clear and the engines are primed, but only for those who are ready to accelerate before turbulence sets in.

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