नागर विमानन महानिदेशालय
DIRECTORATE GENERAL OF
CIVIL AVIATION

INDIA'S STATE ACTION PLAN FOR CO2 EMMISSION REDUCTION IN CIVIL AVIATION

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EXECUTIVE SUMMARY

This is the 3rd Edition of the Indian Action Plan, updated and submitted to the International Civil Aviation Organization (ICAO), in line with the recommendations set forth in Resolution A40-18: Consolidated statement of continuing ICAO policies and practices related to environmental protection - Climate Change. It describes measures adopted by India and prospective plan to limit or reduce CO2 emissions from civil aviation.

After the COVID-19 pandemic, Air Transport has largely recovered. So far, international revenue passenger kilometers (RPK) in India by Scheduled Indian Operators, have grown by 63.9% in FY 2024-25 (Provisional) compared to FY 2019-20 levels. International freight traffic by Scheduled Indian Operators, has also increased by 36.4% over FY 2019-20 levels in compared to FY 2024-25 (Provisional), whereas Domestic flights (Departures) have recorded a growth of 8.2% during the same period

As a continuous work, constantly being improved, it reflects the collaborative effort of various players and reaffirms the commitment of the Indian civil aviation industry to the environment.

A Working Groups have been created to coordinate the elaboration of this Action Plan. The Working Groups, composed of representatives from the Government and the private sector, became a forum for debates and knowledge exchange that contributed to the proper formulation of policies and guidelines to the specificities of the Indian civil aviation industry.

CHAPTER 1: INTRODUCTION

1.1 INTRODUCTION

India is currently one of the fastest growing economies in the world and home to almost one-sixth of humanity. Its growth momentum is an integral part of global development and is essential to global advance in meeting the sustainable development goals. While a number of challenges confront India's development agenda, climate change is an unwelcome constraint thrust on India and the entire world. India's contribution to historical cumulative emissions till 2019, is only about 4.5% of the global total, while its current annual per capita emissions are well below the world average. Thus, its contribution to the making of the challenge of global warming is minimal. Nevertheless, India is committed to be a leader in climate action, by making responsible development choices that move the economy along low GHG emissions pathways towards net zero by 2070. Recognizing that global warming is a global collective action problem, it is committed to addressing the challenge with firm adherence to multilateralism, and, on the basis of equity and the principle of common but differentiated responsibilities and respective capabilities, as embodied in the United Nations Framework Convention on Climate Change (UNFCCC).

India has consistently made ambitious commitments at the UNFCCC and its Paris Agreement, the key multilateral forum for climate change, and has a strong track record of meeting these commitments, despite its minimal responsibility. Building upon Hon'ble Prime Minister Narendra Modi's Panchamrit pledges (five nectar elements) at the 26th Conference of Parties (COP 26) of the UNFCCC in Glasgow, including the target of net-zero emissions by 2070, India updated its NDCs in August 2022 as follows:

1. To put forward and further propagate a healthy and sustainable way of living based on traditions and values of conservation and moderation, including through a mass movement for 'LIFE'– 'Lifestyle for Environment' as a key to combating climate change [UPDATED].
2. To adopt a climate friendly and a cleaner path than the one followed hitherto by others at corresponding level of economic development.
3. To reduce Emissions Intensity of its GDP by 45 percent by 2030, from 2005 level [UPDATED].
4. To achieve about 50 percent cumulative electric power installed capacity from non-fossil fuel-based energy resources by 2030, with the help of transfer of technology

and low-cost international finance including from Green Climate Fund (GCF) [UPDATED].

5. To create an additional carbon sink of 2.5 to 3 billion tonnes of CO_2 equivalent through additional forest and tree cover by 2030.
6. To better adapt to climate change by enhancing investments in development programmes in sectors vulnerable to climate change, particularly agriculture, water resources, Himalayan region, coastal regions, health and disaster management.
7. To mobilize domestic and new & additional funds from developed countries to implement the above mitigation and adaptation actions in view of the resource required and the resource gap.
8. To build capacities, create domestic framework and international architecture for quick diffusion of cutting edge climate technology in India and for joint collaborative R&D for such future technologies.

The continuous increase of greenhouse gases has resulted in increase in average global temperature, which causes extreme weather events and poses risk to economic, social and environmental ecosystems. The consumption of fossil fuels is the biggest contributor to rise in greenhouse gases. Besides power and industries, transportation sector is the biggest consumer of petroleum products.

Given that the demand for transportation will continue to grow in India, it is necessary to formulate strategies to decarbonize the transport sector through concerted efforts such as improving energy efficiency, reducing emissions, and curbing pollution through efficient transport operations. The National Mission on Sustainable Transport for Climate Change combines the medium-term plan and long-term strategy of various transportation ministries for reducing the impact of transportation on climate change.

The mission objectives of the National Mission on Sustainable Transport for Climate Change focus on reducing the environmental impact of transportation which include road, rail, shipping and air. The primary objectives of the National Mission on Sustainable Transport are:

- Reduce emissions from transport sector and promote transition to alternate fuels
- Promote innovative technologies for enhancing energy efficiency of the vehicular and transport systems
- Promote fuel efficient transport modes for passenger, freight, and urban

populations
- Build climate resilient infrastructures to reduce the compounding risks of climate vulnerabilities
- Encourage research and development for future proof and adaptable technologies in transportation and infrastructure

The Mission objectives of achieving sustainability in transportation for climate change have been formulated in line with the priority areas of India's NDC targets.

Additionally, civil aviation is governed by International Civil Aviation Organization (ICAO) to reduce the carbon emissions from international civil aviation. ICAO has its own set of aspirational goals and develops guidelines to achieve those goals. They are:

- 2% improvements in fuel efficiency from 2009
- To achieve Carbon Neutral Growth from 2020 onwards- CORSIA
- Long-term Aspirational Goal- Net Zero Emissions by 2050

In addition to implementation of ICAO SARPs related to environment protection, several voluntary measures are being taken by air transport sector in aircraft operation and at airports in India.

Further, the Government of India has issued a notification for indicative blending percentages of Sustainable Aviation Fuel with ATF as below (initially for international flights):

- 1% in 2027
- 2% in 2028
- 5% by 2030

This document seeks to present a portrait of the Indian aviation sector, its impact on climate change and the mitigation measures in progress and planned to deal with emissions. It aims to showcase the achievements and ambitions of State and aviation stakeholders. With the State Action Plan on CO2 Emissions Reduction, India reaffirms its commitment to achieving the climate goals while making the responsible choices.

2.1 GROWTH IN INDIAN AVIATION SECTOR, EMISSIONS BASELINE AND FORECASTS

The Civil Aviation Industry in India has emerged as one of the fastest growing industries in the country in last few years. India has become the third largest domestic aviation market in the world.

The fundamental drivers of air passenger demand – including population and demographics and increasing incomes – are favorable and supportive of ongoing growth over the longer-term. Over the next 20 years IATA has predicted a growth of 6.1% per year on average. The number of annual air passenger journeys is estimated to increase by more than 350 million over this period, reaching almost 520 million journeys in 2037. In the year 2018, Revenue Passenger Kilometer (RPK) in domestic airline demand growth of 18.6% was three times the global RPK growth of 6.5% as compared to previous year data.

Total passenger in the year 2014-15 was 116.2 million and it has increased by more than 2.1 times by the year 2024-25(P) to reach 239.4 million as shown in Figure 1. The domestic passenger traffic registered a compound annual growth rate 8.96 % (CAGR) of during the period 2014-15 to 2024-25(P) while the international passenger traffic grew at 4.88 % (CAGR) during the same period.

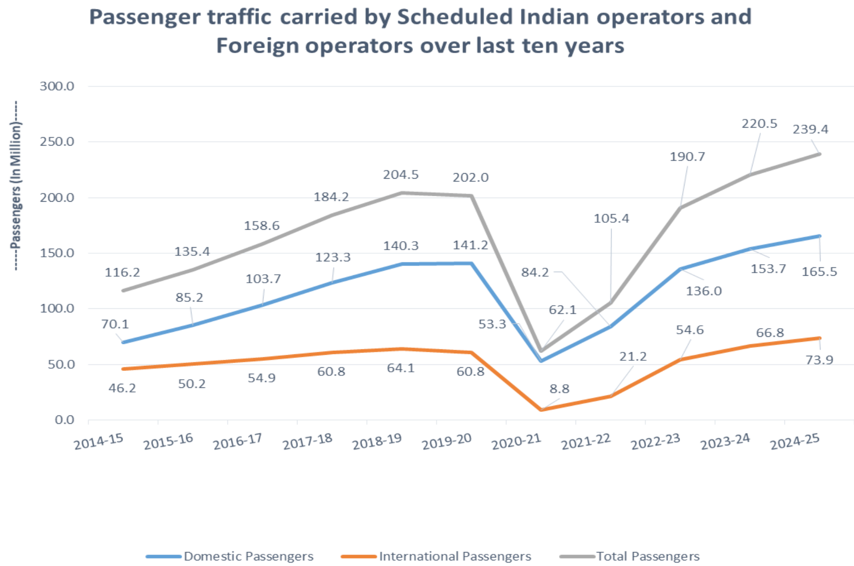


Figure 1

The total departures of all scheduled Indian airlines registered a compound annual growth rate (CAGR) of 6.22% during the period 2014-15 to 2024-25(P) as depicted in Figure 2. During the year from 2014-15 to 2024-25(P), the capacity (ASK) in the domestic market grew at a rate of 9.15% (CAGR) while the demand (RPK) grew at 8.16% (CAGR) during the same period (refer to Figure 3).

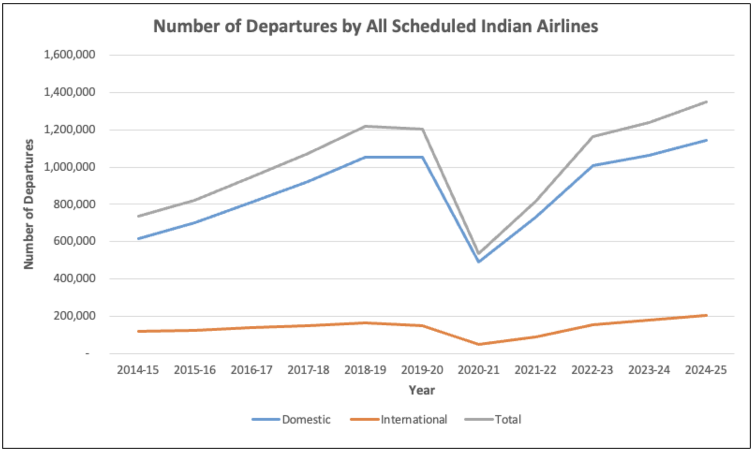


Figure 2

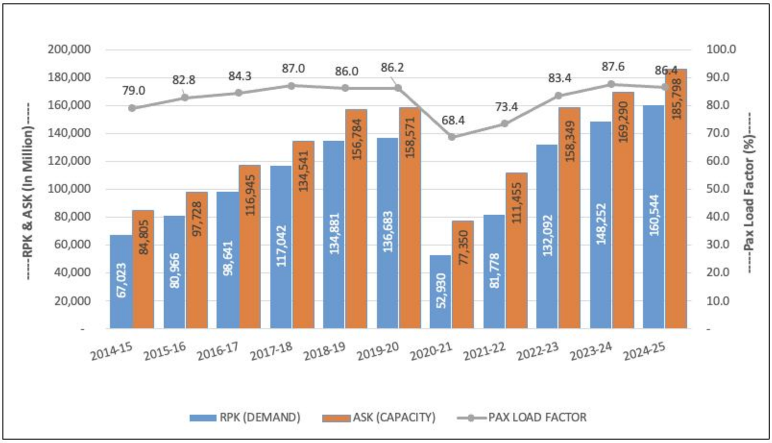


Figure 3

In the year 2024-25(P), both ASK and RPK in the domestic market registered a positive growth compared to the previous year. However, the Passenger Load Factor in the domestic market, fell to 86.4 % as compared to 87.6% of the previous year.

2.2 BASELINE SCENARIO — ACCOUNTING FOR CURRENT AND FUTURE TRAFFIC, FUEL CONSUMPTION AND CO_2 EMISSIONS DATA

The baseline scenario establishes a reference trajectory of CO_2 emissions from Indian scheduled airlines, based on current and projected aviation activity, fuel consumption, and expected traffic growth. This baseline forms the foundation for assessing the impact of mitigation measures, including technological advancements and the deployment of Sustainable Aviation Fuels (SAF), in subsequent analyses.

Data Sources and Methodology

The analysis incorporates historical fuel consumption and emissions data for Indian scheduled airlines operating on domestic and international routes from 2013 to 2024, followed by projections up to 2050. The total CO_2 emissions were derived from recorded aviation activity, with future projections based on an average annual growth rate of 7.8%, consistent with anticipated growth in air traffic and fleet expansion.
The model assumes continuation of current operational efficiency trends and incorporates expected improvements in fleet fuel efficiency in later analyses (technology and SAF scenarios).

Baseline Traffic and Emission Growth

The baseline (business-as-usual) case represents projected CO_2 emissions without the introduction of additional mitigation measures beyond those already achieved through natural fleet turnover and operational optimization.
From the base year 2013, with total emissions of approximately 11,950 kt of CO_2, the trajectory reflects steady growth in both domestic and international operations. Emissions rise gradually to 20,746 kt in 2024 and continue to increase sharply thereafter, reaching approximately 146,228 kt by 2050 under the 7.8% annual growth assumption.
The temporary decline in 2020–2021 corresponds to the COVID-19 pandemic's impact on global air traffic. Recovery occurs rapidly post-2022, returning to pre-pandemic growth patterns by 2023.

Projection Results

Figure 4 illustrates the projected CO_2 emissions under three scenarios:

- **Baseline (blue line):** Represents emissions growth assuming no additional mitigation beyond standard fleet renewal.
- **Technology Improvement (red line):** Includes reductions from anticipated improvements in aircraft efficiency, aerodynamics, and engine performance.
- **SAF Improvement (green line):** Represents additional emission reductions achieved through the progressive introduction of Sustainable Aviation Fuels. While the ambition for SAF blends is currently only for 2027 and 2028, the below trend is based on the lowest ambitious scenario as given in the ICAT feasibility study where the SAF volumes that may be required based on reaching a 40% blend by 2050 has been used.

The baseline scenario follows an exponential growth pattern aligned with air traffic expansion, reaching approximately 1.46×10^5 kt CO_2 by 2050. The technology improvement and SAF scenarios demonstrate potential mitigation pathways, showing cumulative reductions of around 31% and 45% respectively compared to the baseline by 2050.

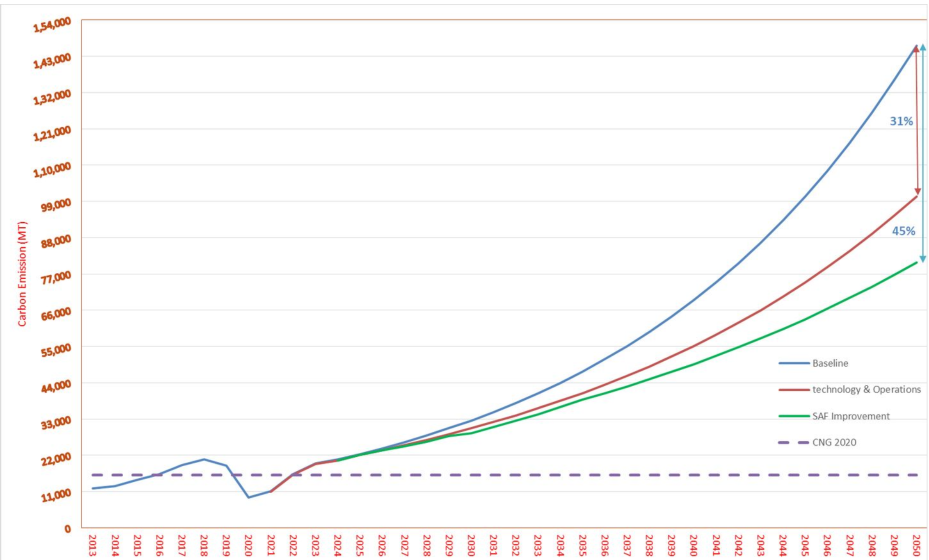


Figure 4

The baseline projection emphasizes the substantial growth in aviation emissions expected under current trends, driven by increasing passenger demand and fleet expansion. The 7.8% annual growth factor reflects the rapid pace of development in the Indian aviation sector, in line with ICAO traffic forecasts for emerging economies.
Without significant interventions, total CO_2 emissions from Indian scheduled airlines are projected to more than twelvefold between 2013 and 2050. This underscores the critical importance of deploying fuel-efficient technologies, sustainable fuels, and operational measures to align the sector's trajectory with long-term global carbon-neutral growth objectives.

The baseline scenario provides a robust reference for evaluating the effectiveness of future mitigation strategies. It reflects the expected evolution of aviation emissions in India, serving as the benchmark against which technology and SAF improvements are assessed.

2.3 MITIGATION MEASURES TO REDUCE CO2 EMISSIONS

The Indian civil aviation sector has undertaken several mitigation measures to reduce greenhouse gas emissions and enhance environmental sustainability.

At the policy level, India has voluntarily committed to the International Civil Aviation Organization's (ICAO) Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA), which aims to cap CO_2 emissions from international flights at 2020 levels.

The National Civil Aviation Policy (NCAP) also promotes sustainability through initiatives for operational efficiency and the use of alternative fuels. Airlines are adopting fuel-efficient aircraft such as the Airbus A320neo and Boeing 737 MAX, which offer lower emissions per passenger-kilometer. Operational improvements such as Performance-Based Navigation (PBN), Continuous Descent Operations (CDO), and flexible airspace management have been implemented to reduce fuel consumption.

On the ground, airports are modernizing their infrastructure by using electric ground support equipment and adopting single-engine taxiing procedures. Renewable energy adoption is also a significant focus, with airports like Cochin, Delhi, and Hyderabad integrating solar power into their energy mix—Cochin International Airport being the world's first fully solar-powered airport. Many airports have also received green building certifications such as IGBC and LEED.

Furthermore, several Indian airports are pursuing carbon neutrality through the Airports Council International’s (ACI) Airport Carbon Accreditation program, and major airport operators like AAI, private stakeholders have announced ambitious targets to achieve net-zero emissions by 2030-2040. These measures collectively contribute to India’s broader efforts to decarbonize the aviation sector while supporting its rapid growth. Details are included in the below sections.

3.1 TECHNOLOGICAL IMPROVEMENTS

3.1.1 CONVENTIONAL AVIATION

3.1.1.1 FLEETS MODERNIZATION & RENEWAL

Indian airlines play an important role in overall aviation emissions reductions. All the Indian carriers have a very young fleet and they operate modern, fuel-efficient aircraft (e.g. Boeing 787 Dreamliner, Airbus 320/B737 NG with sharklets/winglets). According to historic trends in measurements of aircraft fuel usage per seat, modern aircraft are approximately 80% more fuel efficient than aircraft of the 1960s through a combination of increased passenger capacity and technological improvements to improve fuel usage.

Air India operates a significant number of Boeing 787 aircraft. The 787 family provides airlines with unmatched fuel efficiency, resulting in exceptional environmental performance. The Boeing 787 airplane consumes 20% less fuel and produces 20% fewer CO2 emissions. The key to the exceptional performance of the 787 Dreamliner is its suite of new technologies and its revolutionary design. Composite materials make up 50 percent of the primary structure of the 787, including the fuselage and wing. Its wings, tail, nose and flight deck windows have all been engineered for the maximum aerodynamic efficiency, reducing fuel burn. Advances in engine technology are the biggest contributor to overall fuel efficiency improvements on the Dreamliner. The 787 features new engines from General Electric that represent nearly a two generations jump in technology. Further, progressive transition to more efficient new generation aircraft. Air India has ordered 570 latest generation aircraft for its group airlines which include a mix of Wide-Body (Airbus A350, Boeing B787 & B777X) and Narrow-Body (Airbus A320 neo, A321 neo and Boeing 737-Max) aircraft.

As well as number of other carriers are operating A320 Neo aircraft that is powered by quiet, fuel-efficient engines. These next-generation engines compared with conventional engines consume approximately 15 per cent less fuel, reducing CO_2 emissions. Nitrogen oxide emissions are even reduced by 22 per cent thanks to a new combustion chamber, the TAPS II (twin-annular, pre-mixing swirler).

A number of Airlines are also using ATR 72-212A (600 Version) aircraft, which is a state of ART modern aircraft, recognized as the most fuel-efficient aircraft in their category, due to high-tech engines and propeller efficiency. Compared with an equivalent jet aircraft on a 300Nm average trip, the ATR 72 provides a 35% block fuel saving per passenger. Airlines have also inducted B737 Max aircraft to its fleet, which is 14-15% more efficient than its previous fleets.

Aircraft fleet is approved for various PBN specifications inclusive of RNP APCH which supports continuous descent approaches, thereby optimizing airspace usage, reducing fuel consumption, and minimizing emissions.

India has certified a 19 seater Turboprop Aircraft “Hindustan 228” under FAR 23 Normal category. TC Holder “HAL” is working on modification for installation of Li-ion Batteries on Hindustan 228 aircraft in place of existing Ni-Cd Batteries. The installation of new batteries will result in overall weight reduction of Approx. 31.86 kg which in turn results in reduction of fuel consumption per pax.

3.1.1.2 ENGINE-PERFORMANCE IMPROVEMENT

Apart from inducting newer fleets, Indian airlines are continuously focusing on improving the engine performance of all existing aircraft. Airlines have adopted engine ECO wash at regular intervals improves thrust specific fuel consumption. This is a closed-loop system that protects the environment and offers a mobile, fast, repeatable, and efficient process. Deionized, heated and atomized water is sprayed to clean the engine components without the use of any toxic chemicals or detergents. The water is collected and filtered to produce pure, deionized water for reuse. Further, airlines are ensuring Engine Gas path cleaning with a higher frequency, and many airlines are exploring the use of advanced 360-degree foam wash for engine gas path. In addition, all the airlines are carrying out periodic Engine Hot section core wash to improve overall performance and ensure reduced emission from aircraft.

Airlines are also adopting de-rated take offs and de-rated Climb schedules to ensure reduced thrust (de-rate) may be used in both take-off and climb to extend engine life and reduce maintenance cost. Along with this, airlines are also conducting engine condition monitoring on real time basis (24X7), which apart from other benefits such as risk mitigation, fact-based decision making, Combustion Dynamics Monitoring also help in reducing engine emissions.

Airlines are also focusing on scheduled and predictive maintenance that leads to efficient engine function. Engine bleed leak tests are being carried out by airlines for checking the pneumatic system manifolds for any leakage and rectifying the same as necessary.

3.1.1.3 Fuel-Efficiency Improvement

Fuel cost is a major part of overall operating expenses of airlines. Indian carriers along with OEMs are working towards fuel efficiency improvements of their fleets. Some of the key steps taken by airlines are-

- Use of FEGP or GPU and ground air-conditioning unit available in airports, instead of APU while on ground resulted in reduction of aircraft fuel consumption and associated emissions.
- Following IATA best fuel saving practices using “Skybreathe fuel efficiency software” with planned 2% of fuel saving overall. Airlines are also focussing on 2% fuel savings target using measures such as optimization of alternates, reduction in fuel carriage (Destination holding time, Taxi out etc).
- Advised their pilots to adopt One Engine Taxi Departure and Taxi Arrival. Aircraft also uses Packs off departure to ensure engine can attain maximum thrust with minimum fuel consumption.
- Use of data driven provision for additional fuel through monthly reviews, which helps in better fuel planning to avoid carrying extra fuel.

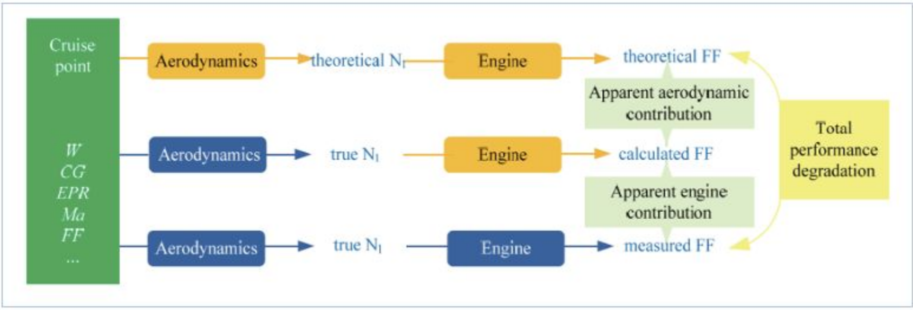
- Deployment of aircraft (e.g. B777-200 LR/300 ER & B787-8) on optimum sectors based
  a. Range, Seating Capacity, passenger load and sector length.
  b. Further on the aircraft performance factor within a fleet type.
- Adopting weight reduction through use of electronic flight bag, thereby reducing 40 kg of on-board documentation per aircraft which results in savings of approximately 1.2 kg/hr of fuel burn for each aircraft.
- Focus on judicious uplift of potable water and meals etc. to reduce on board weight.
- Issue guidelines to pilots to adopt single pact operations for Taxi In & taxi Out and Idle reverse landing
  - Airspace /route DCT
  - EDTO route A/C Optimisation
  - APU Fuel Consumption (Combo unit [Combined Ground Power Unit (GPU) and Aircraft Cooling Unit (ACU)])
  - Packs-off T/O
  - On-board Weight Reduction (LPC, EFB, ACT Removal, Optimizing Water Uplift)
  - Descent Profile Optimization (DPO)
  - Continuous Descent Approach (CDA)
  - Re-Dispatch
  - Performance Factor Optimization

3.1.1.4 AIRFRAME PERFORMANCE IMPROVEMENT

Airframe performance plays a major role in improving overall aerodynamics of Aircraft and overall fuel consumption of aircraft. Some of the key measures adopted by airlines are-

- Airlines are focusing on regular repair of dents, cracks etc. in order to reduce drag at earliest possible opportunity and improve fuel efficiency.
- Airlines carry out regular aerodynamics cleanliness check for airframe drag issues:
  - ✓ Surface Irregularities/Mismatch: Cleaning the fuselage and other surfaces and removing any unevenness or dents etc. especially in the aerodynamically critical areas of the aircraft.
  - ✓ Seal Checks: checking the condition of all seals at flight controls, entry doors etc. and replacing as found necessary.
  - ✓ Flight control rigging: Checking the flight control rigging and adjusting as necessary.

- ✓ Flight instruments: Checking the flight instruments for accuracy and calibrate as necessary.
- Aircraft performance monitoring for any deteriorations and high fuel burn are rectified via corrective maintenance such as cleaning and ensuring properly flushed surfaces.
- Some of the airlines have modified aircraft by adding sharklets. Sharklets save around 3% fuel as compared to non-sharklets aircraft.



AIRCRAFT PERFORMANCE MONITORING

To summarize:

Category	Estimated Emissions Reduction
Fleet modernization	10–20%
Engine performance optimization	2–3%
Airframe drag reduction	2–3%
Weight reduction initiatives	1–2%
Battery retrofit (specific case)	~0.5% per flight

3.1.2 EMERGING TECHNOLOGIES AND INNOVATIVE AVIATION

Advanced Air Mobility (AAM) represents a transformative aviation ecosystem, utilizing next-generation aircraft and cutting-edge technologies to deliver more efficient, sustainable, and equitable modes of transportation. These aircraft incorporate novel design elements and advanced system technologies. While some may resemble traditional fixed-wing aircraft, others feature powered lift and Vertical Take-Off and Landing (VTOL) capabilities, enabling flexible point-to-point operations.

These electric aircraft are designed for short-haul travel / hop-on – hop-off flights (approximately 100–150 km Max.) and various applications including tourism (sight-seeing)/ passenger transit, cargo delivery, air ambulances, and aerial surveys.

India has proactively embraced Unmanned Aircraft Systems (UAS)/drones to mitigate carbon emissions in aviation. Additionally, the country is exploring the integration of AAM solutions to enable large-scale emission reductions across the transport sector.

4.1 ROADMAP FOR CARBON EMISSION REDUCTION VIA AAM AND DRONE INTEGRATION IN INDIA'S CIVIL AVIATION ECOSYSTEM

India's civil aviation sector is undergoing a transformative shift with the integration of Advanced Air Mobility (AAM) and Unmanned Aircraft Systems (UAS). These technologies offer a scalable and sustainable alternative to conventional helicopter and road-based transportation, particularly in urban and remote regions.

4.1.1 COMPARATIVE EMISSION PROFILES

Mode of Transport	Propulsion Type	Typical Use Cases	Emission Profile (CO_2)	Operational Challenges
Road Vehicles	Fossil fuel (diesel/petrol)	Urban commuting, cargo logistics	High (14% of India's energy-related CO_2 emissions)	Congestion, long travel times
Helicopters	Turbine engines (Jet A1)	Emergency services, VIP transport	Very High (per km basis)	Noise, fuel cost, limited access
Electric VTOL (AAM)	Electric propulsion	Urban air taxis, short-haul cargo	Zero tailpipe emissions	Infrastructure, regulatory setup
Drones (UAS)	Electric propulsion	Medical delivery, mapping, surveillance	Zero tailpipe emissions	Payload limitations, airspace integration

4.1.2 STRATEGIC ADVANTAGES OF AAM AND DRONES

Advanced Air Mobility (AAM) and Drone Technologies offer India a unique opportunity to leapfrog traditional transport systems, delivering strategic benefits that align with national goals in sustainability, connectivity, and innovation.

Environmental and Carbon Reduction Benefits

- Zero Tailpipe Emissions: Electric propulsion systems in eVTOLs and drones eliminate direct CO_2 emissions, supporting India's net-zero targets.
- Reduced Noise Pollution: Distributed electric propulsion significantly lowers acoustic footprint compared to helicopters and combustion vehicles.
- Energy Efficiency: AAM aircraft is expected to consume less energy per passenger-kilometre in short-haul operations, especially when powered by renewables.

Operational and Infrastructure Efficiency

- Bypass Ground Congestion: AAM aircraft reduce travel time by flying over traffic bottlenecks, improving productivity and fuel savings.
- Minimal Infrastructure Footprint: Drones and eVTOLs require less physical infrastructure than roads or railways, enabling rapid deployment in remote areas.
- Scalable Logistics: Drone fleets can be scaled for medical, agricultural, and industrial deliveries without major capital investment.

Strategic and Security Applications

- Disaster Response: Drones provide rapid situational awareness and aid delivery in inaccessible regions during floods, earthquakes, or landslides.
- Border Surveillance: Autonomous drones enhance perimeter monitoring and reduce human risk in defence operations.
- Critical Supply Chains: AAM can ensure continuity of essential goods during emergencies, pandemics, or geopolitical disruptions.

The above applications reduces carbon emissions by minimizing number of trips of road vehicles and rescue helicopters/ airplanes operating on conventional fuels.

4.1.3 PHASED IMPLEMENTATION ROADMAP

Phase I: Pre-Operational Setup (2025–2030)

- Establish sandbox environments for low-density manned AAM operations using existing heliports and dedicated routes.
- Deploy drones for logistics, agriculture, and emergency services.
- Develop regulatory frameworks for airworthiness, pilot licensing, and vertiport design.

Phase II: Infrastructure Expansion (2030–2035)

- Build vertiports on rooftops of malls, hospitals, and transport hubs.
- Integrate AAM into urban transport networks with real-time air traffic management.
- Scale drone operations for cargo and surveillance across states.

Phase III: Full Integration and Automation (2035–2040)

- Enable autonomous AAM operations with advanced UTM systems.
- Electrify regional connectivity using STOL and eVTOL aircraft.
- Promote public-private partnerships for cost-effective deployment and equitable access.

4.1.4 POLICY AND INDUSTRY INITIATIVES

- DGCA Guidelines: Issued advisory circulars for AAM aircraft certification, Vertiport commissioning, and crew licensing.
- Industry Collaboration: Indian VCA manufacturers are partnering with airports to integrate AAM into city transport systems.
- Global Recognition: India's AAM blueprint has gained international attention as a model for sustainable mobility.

5.1 OPERATIONAL IMPROVEMENTS

Another focus area for Indian aviation sector is improving operation efficiency. Improving operational efficiency requires a collaborative approach among aviation stakeholders such as Airlines, Air Navigation Service Provider (ANSP), Airport Operators, and Ground Handling Agencies (GHA). All these key stakeholders are working coherently to ensure high operational efficiency in Indian aviation sector. Some of the key measures are:

5.1.1 AIR TRAFFIC FLOW MANAGEMENT (ATFM)

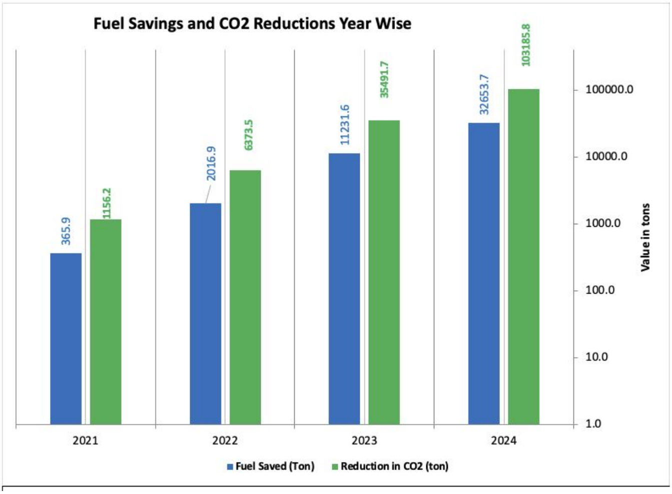
In order to regulate Air Traffic, all the aviation stakeholders have taken a number of initiatives. All the major metro airports in India has implemented Airport Collaborative Decision Making (A-CDM). A-CDM can reduce airport and en-route delays and optimize airport operations, by increasing an efficient turnaround process and improving flight predictability through real time data exchange for air navigation services.

ANSP, Airports Authority of India (AAI) has established a Central Air Traffic Flow Management (C-ATFM) system in India. The C-ATFM system is primarily meant to address the balancing of capacity against the demand to achieve optimum utilization of the major resources viz., Airport, Airspace and Aircraft at every Indian airport where there is a capacity constraint. The C-ATFM network consist of a Central Command Center (CCC) at Delhi supported by Flow Management Positions (FMPs) at major Area Control Centres (ACCs) and ATC towers across the country. The CCC provides ATFM service in conjunction with the FMPs. The C-ATFM system provides ATFM services covering all the four Indian FIRs including the oceanic airspace areas of Bay of Bengal, Indian Ocean and Arabian Sea, designated to India for the provision of ATS Services. This is called Indian Air Traffic Flow and Capacity Management (ATFCM) area.

Airlines are sending updated schedule on a regular basis to ATFM developed by Airport Authority of India (AAI) on which they analyze the density of flights for optimum utilization of the airspace and Aerodrome utilization. Implementation of A-CDM along with ATFM has given significant reduction in aircraft holding overhead the Airport.

The C-ATFM system plays a vital role in enabling optimum utilization of Airports and Airspace, significantly enhancing air safety. Furthermore, its implementation has resulted in substantial fuel savings and a considerable reduction in carbon footprint.

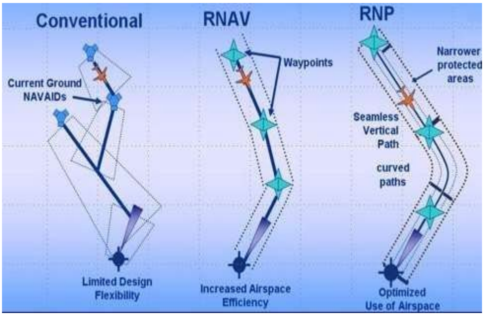
The details in respect of contribution of the C-ATFM system in fuel savings and reduced carbon emissions from year 2021 to 2024 is appended below:



5.1.2 REQUIRED NAVIGATION PERFORMANCE (RNP)

Airports Authority of India (AAI) has been focusing on RNP routes which provide optimum utilization of airspace and air routes for fuel savings since aircraft fleets are approved for various PBN specifications inclusive of RNP APCH.AAI has implemented RNP10, RNP 2 and RNAV 5 specifications on several en-route segments to enhance route efficiency and reduce separation minima. This supports seamless navigation across busy corridors, enabling more direct and fuel-efficient routings. Implementation of 20 NM lateral separation using RCP240 and Space based ADS-B in select airspace has further contributed to enhanced capacity and operational flexibility.

Airports Authority of India has also been implementing RNAV SIDs and STARs as well as RNP procedures including SBAS procedures at airports to support efficient and safe operations. These procedures have significantly improved reliability of operations and terminal airspace efficiency. Airlines are also using User Preferred Route (UPR) system, enabling them to make best use of the available airspace on the operating sector. Filing UPR, in co-ordination with ATC, helps airlines in saving of 1-2% fuel consumption. Direct routings are given by ATC, as far as practical, based on the traffic scenario. It is estimated that 1 min of direct routing can save around 36 kgs of fuel.



Air Traffic Services using SPACE-BASED ADS-B

5.1.3 ELECTRIFICATION OF GROUND FLEET

Airports, Airlines, Ground Handling Agencies and other aviation stakeholders are progressively shifting towards electric vehicles. In few Airports, airlines are also using battery swapping system for electrical tugs and all tarmac operations (tail to tail) are being carried out by electrical tug. Delhi Airport has also set up electric charging facilities for electric vehicles and have deployed electric buses for passenger movement in the city side within the airport. At many Airports Ground Handling Service Providers have introduced Battery Powered Electric Vehicles which has reduced emissions.

5.1.4 OTHER OPERATIONAL MEASURES

Apart from the above listed measures some additional measures being adopted by Airlines and Airports are:

Smart Tracking:
Airlines have adopted flight tracking mechanism and well-defined procedures for flight tracking have been put into place. In addition, smart tracking of old vehicles by service

provider on GSE are also being used. With the tracking and monitoring, Airlines and GSEs are ensuring that all performance records of GSE are checked and improvements as necessary are carried out.

Continuous Climb & Descent Operations (CCO):
Airlines are focusing on Continuous Climb and Descent Operations in coordination with ATC. It is estimated that CCO can save around 270 Kgs of fuel per flight, whereas CDO can save around 200 Kgs of fuel per flight.

Airlines have adopted improved flight planning system and fuel calculation methods. In this initiative, all the fixed fuel parameters are converted to system calculated values. By optimizing the flight plan calculations, approximately 400kg fuel uplift is reduced per flight, and also resulting in reduction in carbon emission.

Optimum Centre of Gravity:
The Center of Gravity limits are defined for each aircraft to make sure the aircraft maintains a safe flight through all phases of flight. Considering the fuel burn, a forward CG will lead to an extra fuel burn and an aft CG will lead to a lower fuel burn. Airlines have adopted a practice to place the CG aft, ensuring to stay within the safety limits. This helps in planning the CG aft, whenever operationally possible and thereby leading to lower fuel burn and CO_2 reduction.

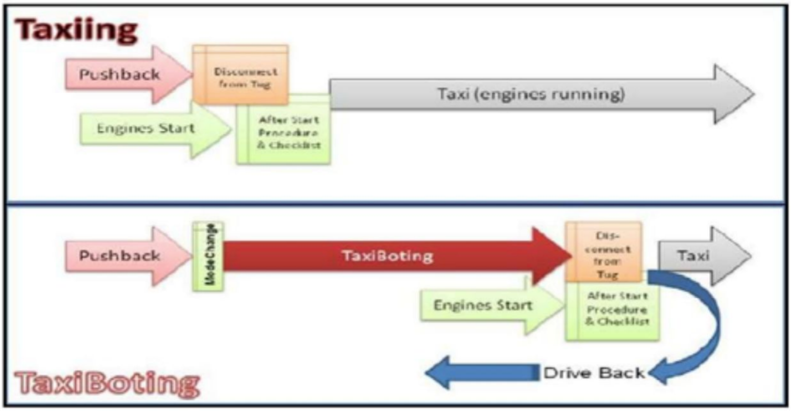
Idle Thrust Reverser:
If adequate runway length is available, all the landings are preferably done with idle thrust reverser by Airlines. This brings a fuel savings of 13.7 kg per landing, which results in reduction of 43.25 kg of CO_2.

Improved Method for Calculating DEST Hold Fuel Requirement:
DEST Hold fuel is calculated to cover anticipated hold over destination airport due to traffic congestion and weather. Airlines have adopted improved calculation methodology for DEST Hold. This has increased pilot confidence on CFP fuel calculation and has helped to reduce the average Pilot extra fuel to below 100kg.

Cost Index:
Airlines have converted from Mach flying to Dynamic Cost Index flying which results in reduction of Fuel consumption and Carbon dioxide emissions. In addition, airlines have also reduced contingency fuel from 10% to 5% based on routes and destination airport condition.

5.1.5 TAXIBOT OPERATION

Airports and Airlines have adopted additional initiatives to enhance on-time performance and minimize ground delays. A significant step in this direction is the deployment of TaxiBot at Delhi and Bengaluru airports. Several Airlines, including Air India, Air India Express and Quick Jet are now utilizing TaxiBot for regular operations. Commercial use of TaxiBot is currently underway at both Delhi and Bengaluru airports, marking a key advancement in the implementation of sustainable green taxiing solutions.



TAXIBOTING Operation at Airports

6.1 ALTERNATIVE FUELS

BIOFUELS PRODUCTION:

The Indian government supports the production and use of multiple biofuels through various policies and financial support. Climate mitigation, in the form of GHG emissions reductions, is main goal of these policies. This will also result in reduced import dependency in the energy sector and promote rural development & job creation. A key rationale for utilising domestic feedstock's and wastes is the broader environmental benefits of reducing the burning of residues (e.g., rice straw) and other wastes, which cause widespread pollution and associated health issues.

NATIONAL BIOFUELS POLICY:

In 2018, India released its National Policy on Biofuels, which set blending targets for ethanol (20% blending by 2030) and biodiesel (5% by 2030), feedstock requirements for different fuels and laid out the responsibilities of 11 ministries to coordinate government actions. Beyond blending targets, India established guaranteed pricing, long-term ethanol contracts, and technical standards and codes. Financial support for building new facilities and upgrading existing ones was also provided. In 2022, due to the success of the ethanol sector, the Government preponed the 20% volume blending target for ethanol by 5 years to 2025-26.

Sugarcane provides most ethanol production, with the remainder from food grains such as maize and surplus rice stocks determined by the Food Corporation of India. The Indian government gives separate pricing to maize-based ethanol.

The NBP also includes advanced biofuels, which are produced from feedstocks (i.e., agricultural and forestry residues, such as rice and wheat straw, corn cobs and stover, and bagasse) or non-food crops (i.e., grasses and algae), as well as industrial waste and residue streams. These advanced biofuels must have low CO_2 emission or high GHG reduction and not compete with food crops for land use. Fuels such as second-generation (2G) ethanol, drop-in fuels, algae-based 3G biofuels, bio-CNG, bio-methanol, dimethyl ether (DME) derived from bio-methanol, bio hydrogen, and drop-in fuels with municipal solid waste (MSW) as the feedstock material will qualify as advanced biofuels.

BIODIESEL

Conventional diesel accounts for approximately 87% of the total road transport fuel demand. Blending biofuel into transportation fuel enables India to reduce its dependence on foreign oil imports. Table 1. Shows the production of biodiesel (Fatty Acid Methyl Esters, FAME) in India, the number of bio refineries, and the current blend rate in the diesel pool.

Source: National Biofuels Policy 2018, [Road Transport | Transport Sector in India]

	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024 f
Production (million litres)	152	158	170	185	230	200	180	185	200	226
No or bio refineries	6	6	6	6	6	6	6	7	10	12
Nameplate capacity (ML)	500	550	600	650	670	580	520	577	600	820
Biodiesel on-road use (ML)	41	48	72	83	100	50	10	40	40	105
Diesel (on-road use) (BL)	52	55	56	59	60	44	53	57	62	66
Blend rate %	0.08	0.09	0.13	0.14	0.17	0.11	0.02	0.07	0.06	0.16

Table 1. Biodiesel production and use in India (f=projected)

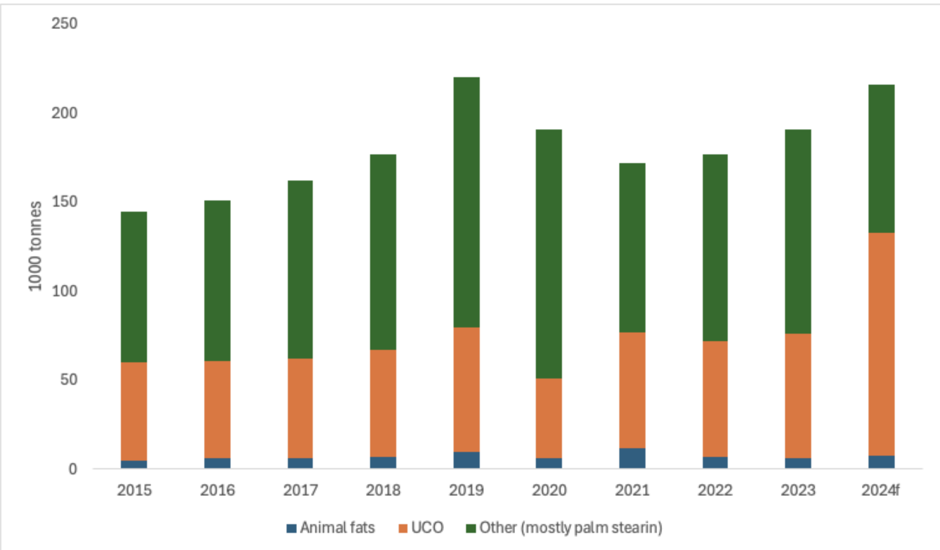


Figure 1. Feed Stocks used for Biodiesel Production in India

Current biodiesel production mainly depends on feedstock such as animal fats, non-edible oils, used cooking oil (UCO), and imported palm oil and palm stearin. Many producers utilized palm acid oil (PAO) in 2021 due to a limited supply of animal tallow. Below illustrates the difference between the nameplate capacity and actual biodiesel production in India over the past few years.

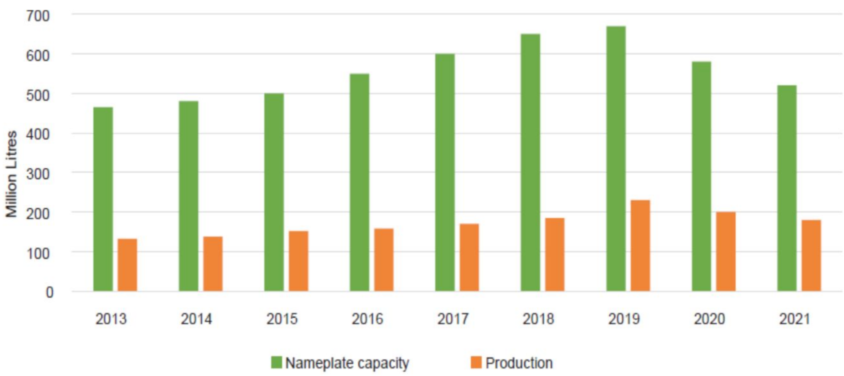


Figure 2. Nameplate capacity vs actual production of biodiesel in India.

India's biodiesel industry is struggling with the availability of feedstocks. Low yields of Jatropha and other inedible oilseeds on non-arable lands make cultivation uneconomical.

Non-edible sources are some of the country's most promising sources of biodiesel production. The major barriers to the supply of feedstocks such as UCO include a poor collection mechanism, a disrupted supply chain network, and a lack of proper regulation mechanisms.

Following a business-as-usual trend rate of diesel consumption growth over the past decade, India is expected to consume approximately 92.85 million tonnes of conventional diesel by 2030. A 5% blending requirement will require about 4.64 million tonnes of biodiesel annually (**refer fig 1**). The high cost of biodiesel, compared to conventional diesel, is a barrier to its large-scale commercialisation.

BIOETHANOL

With ethanol blending, India has a promising opportunity to reduce its dependence on imported oil while addressing environmental concerns. Production volumes of bioethanol are shown in Table 2. Over 6 billion litres of ethanol are produced in 270 bio refineries with an 11.5% blending rate into petrol.

	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024f
Production (million litres)	2,292	2,061	1,671	2,692	2,552	2,981	3,280	5,300	6,500	6,350
No or bio refineries	160	161	161	166	170	220	231	252	263	270
Nameplate capacity (ML)	2,100	2,210	2,215	2,300	3,000	3,500	4,300	5,700	10,820	14,500
Bioethanol on-road use (ML)	425	450	675	1,500	1,890	2,100	3,695	5,140	6,340	6,245
Petrol/ gasoline (on-road use) (ML)	30,823	32,994	37,098	40,367	42,496	40,741	45,453	50,150	53,000	54,500
Blend rate %	1.4	1.4	1.8	3.7	4.4	5.2	8.1	10.2	12.0	11.5

Table 2. Production of Ethanol in India

As shown in Figure 2 several feed stocks are used for ethanol production, with sugarcane syrup and B-heavy molasses predominant.

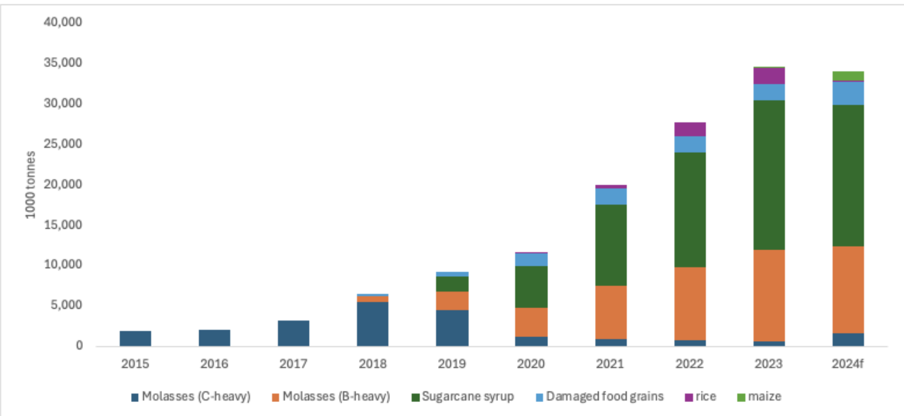


Figure 3. Feedstocks used for bioethanol production in India

Blending ethanol with petrol began in 2001 as a pilot project. The ethanol industry has since expanded significantly, and an initial target of 20% ethanol blending by 2030 was modified to a 20% target by 2025.

In India, ethanol is primarily produced as a by-product of sugar manufacturing, and large sugar companies are among the leading ethanol producers in the country. Major sugarcane-producing states, such as Uttar Pradesh, Maharashtra, Tamil Nadu, Karnataka, Andhra Pradesh, and Bihar, account for the majority of sugar mills. The major producers of ethanol are all sugar companies.

Sugar company	State	Cane Crushing capacity, (t/day)	Ethanol capacity, (m^3/day)
BHSL (Bajaj Hindustan Ltd)	Uttar Pradesh	136,000	800
BCML (Balrampur Chinni Mills)	Uttar Pradesh	76,500	520
Dalmia Bharat Sugar & Ind Ltd	Uttar Pradesh, Maharashtra	35,000	305
Shri Renuka Sugars Ltd	Karnataka, Maharashtra	46,000	930
Triveni Engg & Sugar Industry	Uttar Pradesh	-	660

Table 3. Major Ethanol Producers in India

To accommodate the use of 20% ethanol blends, the Indian government is actively promoting the domestic manufacturing of flex-fuel vehicles that can use high blends of ethanol, offering greater flexibility. Additionally, domestic production and use of electric vehicles are promoted, which will ultimately lead to a reduction in gasoline demand.

Ethanol production capacity more than doubled in the last four years to reach 16.23 billion litres (1,623 crore litres) as of September 18, 2024. In the Ethanol Supply Year (ESY), which runs from November to October, the blending of ethanol with petrol stood at 3.8 billion litres (380 crore litres) compared with a blending percentage of 1.53% in ESY 2013-14.

Given the shortfall expected to meet the 20% ethanol blending target, the Indian Government has taken various steps to increase the production and utilization of ethanol. The Government has announced an Ethanol Interest Subvention Scheme(s), extending financial assistance in the form of interest subvention @ 6% per annum or 50% of the rate of interest charged by banks/financial institutions, whichever is lower for five years, including a one-year moratorium.

BIOGAS

Biogas is an energy-rich gas produced by anaerobic decomposition or thermochemical conversion of biomass. Biogas is mostly comprised of methane (CH4) and carbon dioxide (CO2). The methane content of raw (untreated) biogas typically ranges from 40% to 60%, with CO2 accounting for the majority of the remainder, along with small amounts of water vapour and other gases. Biogas can be burned directly as a fuel or treated to remove the CO2 and other gases for use, just like natural gas. Treated biogas may be called renewable natural gas or bio methane. There are technology pathways that can utilise biogas or renewable natural gas for the production of sustainable aviation fuel. However, it is mostly used for power production in India.

Compressed Biogas (CBG) can be produced from waste, including municipal solid waste, sludge from wastewater treatment plants, market residues, agricultural residues, cattle dung, sugarcane press mud, sago waste, etc.

The Indian government launched the Sustainable Alternative to Affordable Transport (SATAT) in October 2018 to promote the technology. The scheme aimed to produce 15 million metric tonnes (MMT) of CBG from 5,000 plants by 2023. Public sector undertakings, oil marketing companies (OMCs), including Indian Oil, BPCL, HPCL, GAIL, and IGL, have partnered with potential entrepreneurs under this initiative to set up plants and supply CBG for sale as automotive and industrial fuels.

The SATAT initiative has the potential to increase the availability of more affordable transport

SUSTAINABLE AVIATION FUELS

The 41st ICAO General Assembly adopted "*Long-Term Aspirational Goal (LTAG)*" for international aviation of net-zero carbon emissions by 2050 in support of the UNFCCC Paris Agreement's temperature goal. This is a historic agreement that reinforces the leadership of ICAO on issues relating to international aviation and climate change.

The LTAG does not attribute specific obligations or commitments in the form of emissions reduction goals to individual States. Instead, it recognizes that each State considering its special circumstances and capabilities (e.g., the level of development, maturity of aviation markets, sustainable growth of its international aviation, just transition, and national priorities of air transport development) will inform its ability to contribute to the LTAG within its own national timeframe. Each State will contribute to achieving the goal in a socially, economically and environmentally sustainable manner and in accordance with its national circumstances.

The LTAG report shows that SAF has the greatest potential to reduce CO_2 emissions from International Aviation.

With the concept of de carbonization of aviation sector, Ministry of Petroleum & Natural Gas had constituted a Bio-ATF Program Committee to take forward the Bio-Aviation Turbine Fuel program in the country, to promote the use of clean fuel in aviation in India.

Further, the Government of India has issued a notification for indicative blending percentages of Sustainable Aviation Fuel with ATF as below (initially for international flights):

a. 1% in 2027,
b. 2% in 2028,
c. 5% by 2030

Three different scenarios for SAF demand to 2050 were developed based on the forecast for international flights only and for International and domestic flights combined taking into consideration the ICAO ACT SAF report for India. While the ambition for SAF blends is currently only for 2027 and 2028, these scenarios give an idea of the SAF volumes that may be required based on reaching a 40%, 50% and 60% blend by 2050.

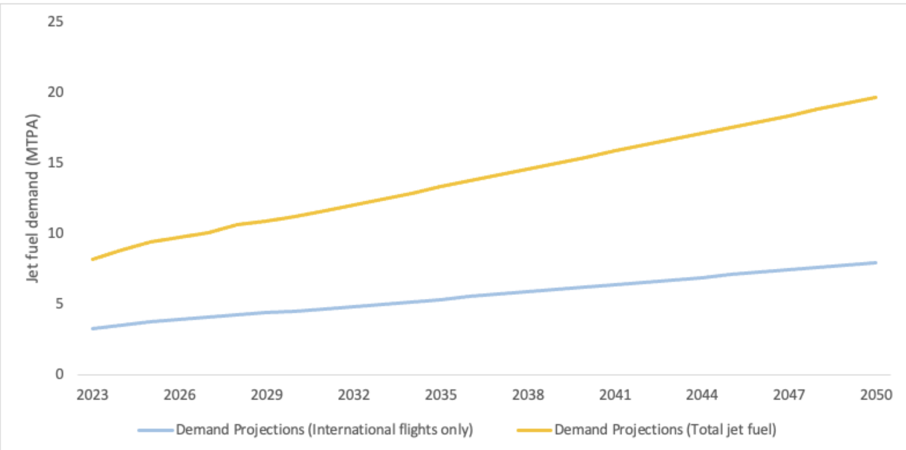


Figure 4: Forecast for jet fuel demand to 2050 for total jet fuel (International and domestic flights) and jet fuel demand for international flights only

Table 4 shows the three Scenarios and the estimated volumes of SAF that will be required to meet these demands. Scenario 1 (S1) is based on reaching a 40% blend by 2050; Scenario 2

(S2) is based on reaching a 50% blend by 2050; and Scenario 3 (S3) is based on reaching a 60% blend by 2050.
Source: ICAO SAF Feasibility Report for India.

Year	SAF% S1	Int only (Mt)	Total (Mt)	SAF% S2	Int only (Mt)	Total (Mt)	SAF% S3	Int only (Mt)	Total (Mt)
2027	1	0.041	0.101	1	0.041	0.101	1	0.041	0.101
2028	2	0.086	0.214	2	0.086	0.214	2	0.086	0.214
2030	5	0.225	0.56	5	0.225	0.56	5	0.225	0.56
2035	10	0.54	1.33	10	0.54	1.33	15	0.81	2.00
2040	20	1.25	3.09	25	1.56	3.86	30	1.87	4.63
2050	40	3.19	7.87	50	3.99	9.84	60	4.78	11.80

Table 4.SAF demand (as a % blend) for three scenarios based on Jet Fuel demand for International (Intl) flights only or for total jet fuel demand.

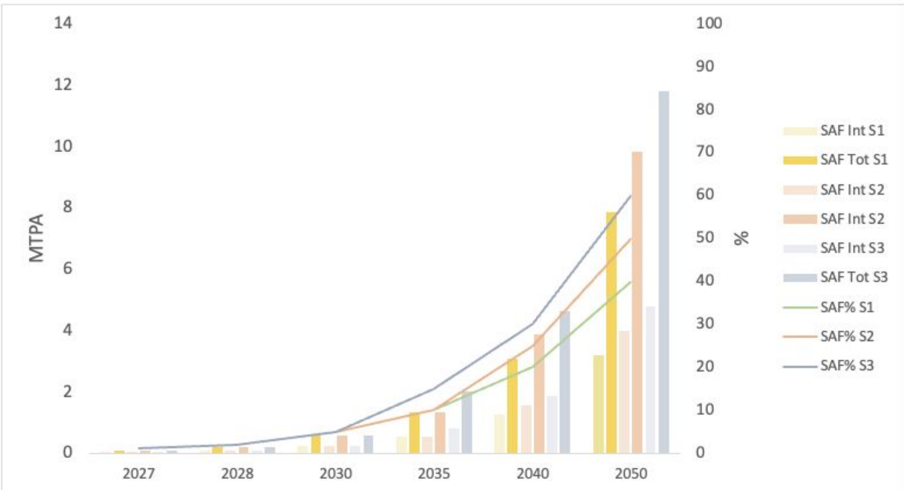


Figure 5. SAF demand (as a % blend) for three scenarios based on Jet Fuel demand for International (Intl) flights only or for total jet fuel demand.

Potential Production Volumes in India Based on Available Feed Stocks

The high estimate is the total feedstock volume, while the low estimate is 50% of the total feedstock volume, except in the case of sugarcane bagasse where the low estimate is based on current excess volumes after bioenergy applications were excluded. In the case of 1G ethanol, the sugarcane and grain feed stocks were not considered, but the ethanol capacity of all the existing facilities (high estimate), while the low estimate for 1G ethanol is 50% of the current ethanol plant capacity. As shown in Section 2, 1G ethanol production fluctuates based on limits placed on feedstock use, while none of the plant operate at full capacity. Currently, 1G ethanol is used for blending with petrol to meet the government target of 20% blends. However, it is assumed that initial alcohol-to-jet facilities will be able to use 1G ethanol while 2G ethanol is being developed.

Feedstock/Technology	Feedstock volumes LOW (Mt/Year)	Feedstock volumes HIGH (Mt/Year)	Comment
UCO/HEFA	1.25	2.5	Low- 50% of UCO goes to biodiesel. High - all UCO is diverted to HEFA
1G ethanol/ATJ	7	14	High is total capacity of current ethanol facilities in India. Low is 50% ethanol going for petrol blending and the remainder being available for SAF production
Sugarcane bagasse and ETJ	30	120	High is total bagasse volumes. Low is surplus bagasse after bioenergy. Conversion 0.18 tonnes ethanol per tonne of bagasse
Rice straw and ETJ	77	154	High is total rice straw used for 2G ethanol and SAF. Low is 50% of rice straw used. Conversion 0.18 tonnes ethanol per tonne of bagasse
MSW and Gasification/FT	19.96	39.9	Treated and landfilled MSW

Table 5. Availability of key feedstocks in India based on a low and a high estimate

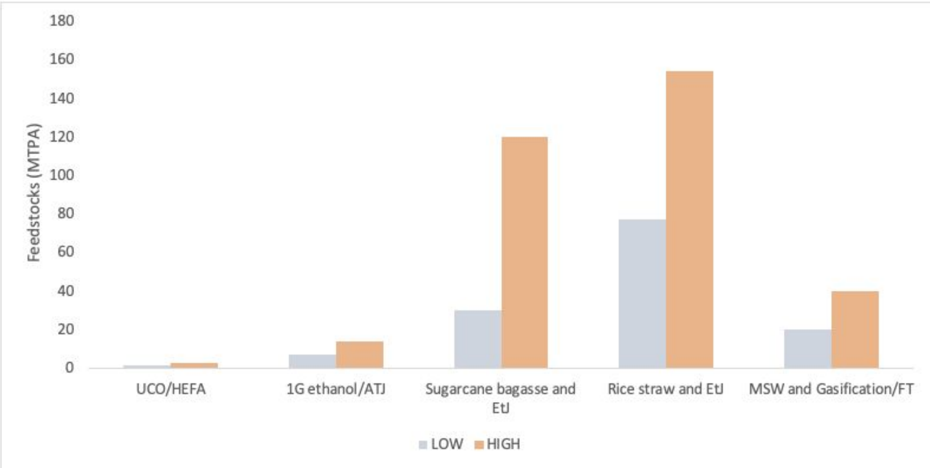


Figure 6. Feedstock availability based on low and high estimates for the main biogenic feedstocks only

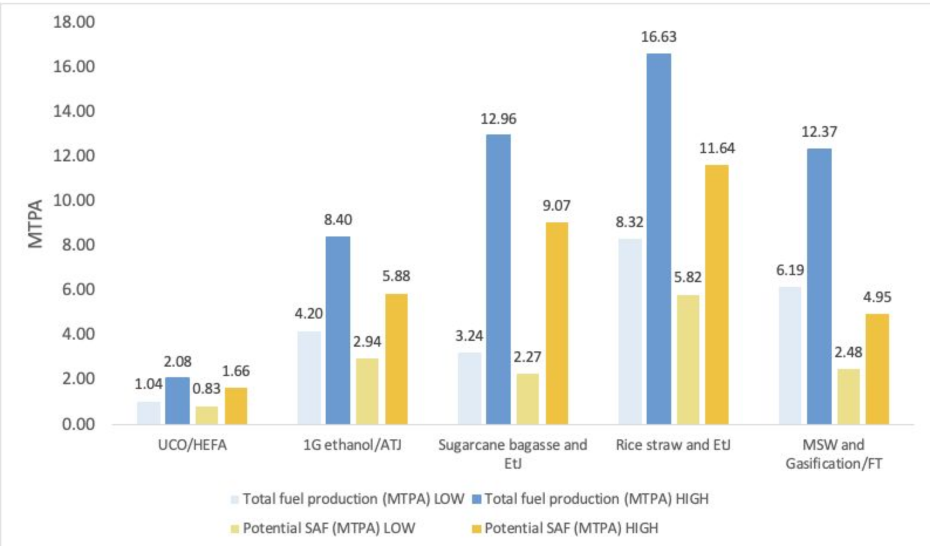


Figure 7. Potential total Biofuel and SAF volumes based on assessed feedstock availability (MTPA)

SAF production volumes could range between 14.33 MTPA (17.92 BLPY) and 33.2 MTPA (41.5 BLPY) based on biogenic feedstocks alone. This would be more than enough SAF to meet demand for 2050, even at 70% blends (Figure 5)

Feedstock/ Technology	Total fuel production (MTPA)	Total fuel production (MTPA)	Potential SAF (MTPA)	Potential SAF (MTPA)	SAF in BLPY	SAF in BLPY
	LOW	HIGH	LOW	HIGH	LOW	HIGH
UCO/HEFA	1.04	2.08	0.83	1.66	1.04	2.08
1G ethanol/ATJ	4.20	8.40	2.94	5.88	3.68	7.35
Sugarcane bagasse and EtJ	3.24	12.96	2.27	9.07	2.84	11.34
Rice straw and EtJ	8.32	16.63	5.82	11.64	7.28	14.55
MSW and Gasification/FT	6.19	12.37	2.48	4.95	3.09	6.18
TOTAL	**22.98**	**52.44**	**14.33**	**33.20**	**17.92**	**41.50**

Table 6. Potential Production of Total Fuels and SAF based on different Feedstock's as Illustrated in Figure

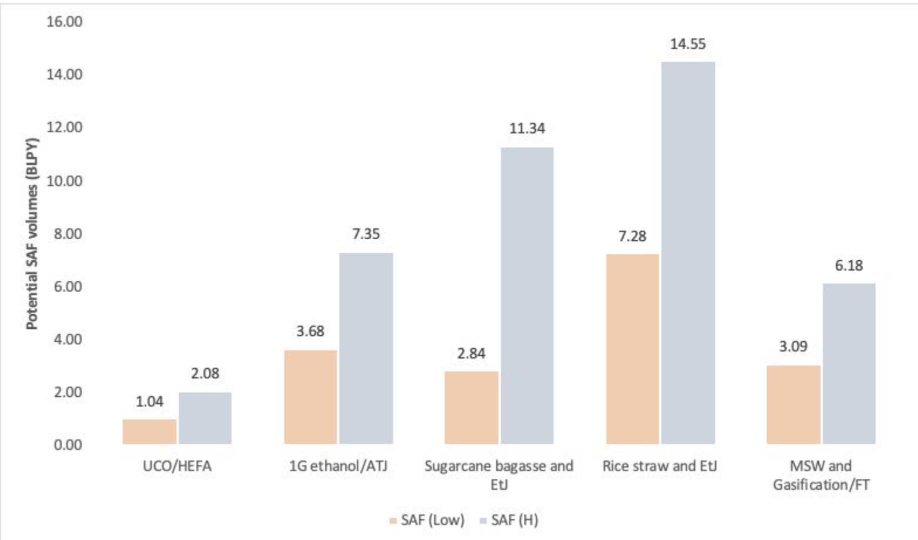


Figure 8. Breakdown of low and high SAF volumes potential from different feedstock's (BLPY)

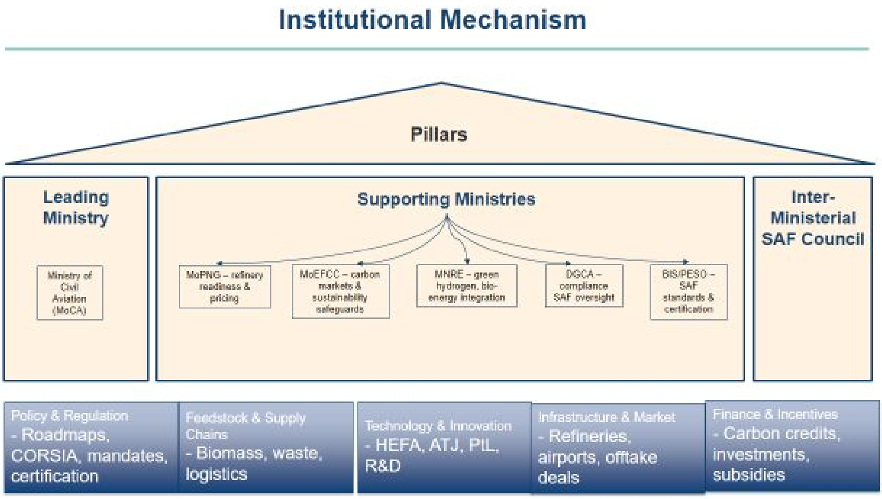
The preceding assessment of potential SAF production from the main feedstocks did not consider estimates for additional SAF production through technology pathways such as power-to-liquids and waste gas (or syngas) fermentation. However, utilisation of these gases can produce significant volumes of SAF in excess of the estimates based on bio based feedstocks.

SAF ROADMAP

India's Sustainable Aviation Fuel (SAF) sector is emerging as a game-changer in the journey towards green aviation and global market size projected to be USD 25 billion by 2030. With abundant biomass and agricultural residues, India has the potential to produce 8–10 million tonnes of SAF annually by 2040. India's target is to achieve 5% blending of SAF by 2030, reducing up to 25 million tonnes of CO_2 every year. India is set to play a vital role in shaping a cleaner, resilient, and globally trusted aviation supply chain.

Objectives
• Mitigate GHG emissions from aviation (align with Net Zero 2070) • Meet ICAO-CORSIA & global climate obligations • Enhance energy security and reduce ATF import dependence • Enable carbon market participation (CCTS, Article 6 ITMOs) • Foster green innovation, rural employment & bio economy • Position India as a global SAF hub.

Reform Direction
• Policy & Legislative Reforms ➢ SAF blending mandates (concerned Ministries) ➢ Feedstock sustainability standards ➢ Carbon market frameworks (CCTS, Article 6) • Infrastructure Development ➢ Develop SAF blending infrastructure in Oil marketing companies • Process Reforms ➢ Single-window clearance for SAF plants ➢ SAF registry system ➢ Inter-ministerial SAF Steering Committee • Technology & Market Reforms ➢ Viability Gap Funding (VGF) & Production-Linked Incentives (PLI) ➢ Tax & fiscal reliefs for SAF producers


Institutional Mechanism
Pillars
Leading Ministry
Ministry of Civil Aviation (MoCA)
Supporting Ministries
MoPNG – refinery readiness & pricing
MoEFCC – carbon markets & sustainability safeguards
MNRE – green hydrogen, bio-energy integration
DGCA – compliance SAF oversight
BIS/PESO – SAF standards & certification
Inter-Ministerial SAF Council
Policy & Regulation
- Roadmaps, CORSIA, mandates, certification
Feedstock & Supply Chains
- Biomass, waste, logistics
Technology & Innovation
- HEFA, ATJ, PtL, R&D
Infrastructure & Market
- Refineries, airports, offtake deals
Finance & Incentives
- Carbon credits, investments, subsidies

7.1 MARKET BASED MEASURES

CORSIA – Carbon Offsetting and Reduction Scheme in International Aviation

1. In 2016, the ICAO adopted Carbon Offsetting & Reduction Scheme for Aviation (CORSIA) as a global market-based measure to reduce emissions from international aviation which require offsetting of emissions above a baseline value. CORSIA is the first global market-based measure for any sector and represents a cooperative approach that moves away from a "patchwork" of national or regional regulatory initiatives. It offers a harmonized way to reduce emissions from international aviation, minimizing market distortion, while respecting the special circumstances and respective capabilities of ICAO Member States.

2. CORSIA complements the other elements of the basket of measures by offsetting the amount of CO_2 emissions that cannot be reduced through the use of technological improvements, operational improvements, and sustainable aviation fuels with emissions units from the carbon market.
   The following have been adopted under CORSIA in the 41st ICAO General Assembly:

   i. Use of 2019 CO_2 emissions as the CORSIA baseline for the pilot phase (2021 – 2023);
   ii. Use of 85% of 2019 CO_2 emissions as the CORSIA baseline after the pilot phase (2024 – 2035); and
   iii. Changes to the percentage of the sectoral and individual operator's growth factors for the calculation of offsetting requirements under CORSIA as follows:
      a) 100% sectoral and 0% individual for 2030 – 2032 (Previously 70% sectoral & 30% individual) and
      b) 85% sectoral and 15% individual for 2033 – 2035 (Previously 30% sectoral & 70% individual).

3. Airlines can either use Sustainable Aviation Fuel (SAF) or offset their emissions by purchasing carbon credits from ICAO approved Emissions Unit Programmed.

4. CORSIA includes specific methodologies that allow aircraft operators to reduce their offsetting requirements through the use of SAF and Lower Carbon Aviation Fuels (LCAF), including globally-accepted sustainability criteria and life cycle methodologies. These are being developed by the ICAO Committee on Aviation Environmental Protection (CAEP), through its Fuels Task Group (FTG).

India opted not to enter the scheme voluntarily and will start offsetting from 2027 on. Nevertheless, CORSIA's obligations related to monitoring, reporting and verification (MRV) of emissions are already in place.

CAR Section 10 Series C part 1 on "CORSIA"

India has issued CAR Section 10 Series C part 1 on "CORSIA". This CAR has been issued to formulate regulations towards MRV and offsetting requirements for all aeroplane operators based on International Civil Aviation Organization's International Standards and Recommended Practices (SARPs) as contained in Annex-16, Environmental Protection, Volume-IV "Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA)".

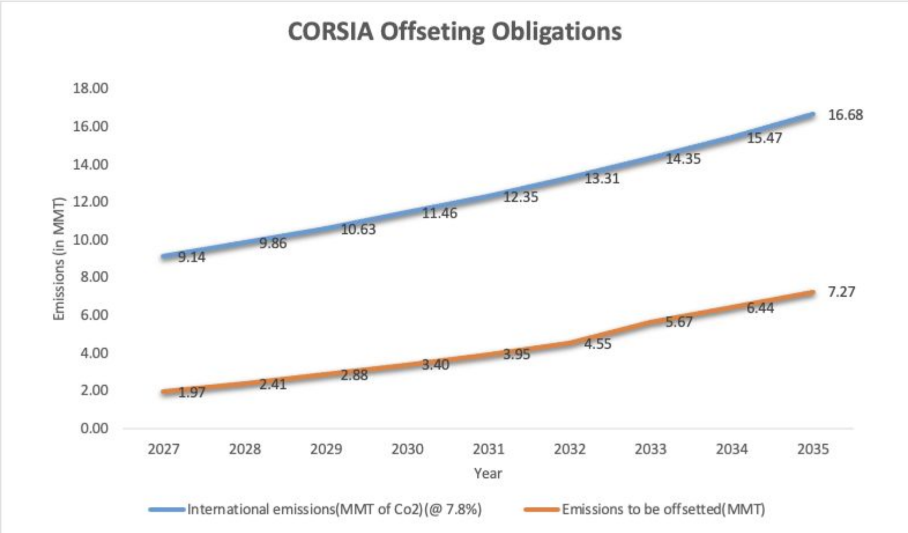
a) The requirements as prescribed in this CAR are applicable to an aeroplane operator that produces annual CO_2 emissions greater than 10,000 tonnes from the use of an aeroplane(s) with a maximum certificated take-off mass greater than 5,700 kg conducting international flights on or after 1 January 2019, with the exception of humanitarian, medical and fire fighting flights.

The international flights preceding or following a humanitarian, medical or fire fighting flight will be exempted provided such flights were conducted with the same aeroplane, and were required to accomplish the related humanitarian, medical or fire fighting activities or to reposition thereafter the aeroplane for its next activity. The aeroplane operator shall provide supporting evidence of such activities to the verification body or, upon request, to DGCA.

In addition to the above CAR, following circulars have also been issued for further guidance of operators.

Noise Management of Aircraft Operations at Airport
Climate Change Initiatives in Civil Aviation
Circular on Guidance for Airline Operators on Emissions Monitoring Plan
Circular on Guidance for Airline Operators on Annual Emissions Report and Annual Verification Report

Below figure gives the illustration of India's Offsetting Obligations starting from year 2027 with 85% of 2019 baseline and the applicable SGF and IGF.



8.1 AIRPORT INITIATIVES

8.1.1 SUSTAINABLE PRACTICES AT THE AIRPORTS

- Solar Power Leadership
  India is making impressive strides in integrating solar power into its Airports. **Cochin International Airport** in Kerala holds the distinction of being the world's first fully solar-powered airport, generating enough energy to meet its own needs and even supplying excess power back to the grid. The **Airports Authority of India (AAI)** has also been actively installing solar power plants across various airports, with **73 airports** switching to 100% green energy usage since 2014.

- Green Transportation
  India is making significant progress in green transportation at its airports. Delhi Airport has launched the largest Electric Vehicle (EV) program among Indian airports, deploying 57 EVs for airport operations, with plans to add more. These EVs help reduce greenhouse gas emissions and support the airport's goal of becoming a Net Zero Carbon Emission Airport by 2030. Additionally, 66 Indian airports are now operating on 100% green energy, as part of the government's push toward carbon neutrality. The Airports Authority of India (AAI) has also introduced the SUGAM Green Airports Mission, which focuses on sustainable infrastructure, energy-efficient buildings, and renewable energy adoption.

- Water Harvesting and Sustainable Aquaculture
  India is making strides in water harvesting and sustainable aquaculture at its airports, with Cochin International Airport (CIAL) leading the way. CIAL has successfully implemented Total Sustainability Management (TSM) at its golf course, where treated water from the airport's sewage treatment plant is used for water harvesting through 12 artificial lakes. This ensures efficient water utilization while maintaining a green landscape. These efforts not only promote environmental sustainability but also generate additional revenue through high-quality fish production. CIAL's approach to photovoltaic agriculture farming, combining organic vegetable cultivation with solar fields, has also been a major success, yielding 90 metric tons in the last harvest.

- Smart Parking and Digitalization
  Indian airports are embracing **smart parking** and **digitalization** to enhance efficiency and passenger convenience. Airports are integrating **automated parking systems** with real-time availability tracking. **Delhi Airport** has introduced **AI-powered parking management**, reducing congestion and optimizing space utilization. **Chennai Airport** has implemented **contactless payment solutions** for parking, allowing seamless transactions.

The **DigiYatra initiative** is revolutionizing air travel with **facial recognition-based boarding**, eliminating the need for physical documents. **SITA's Smart Path technology** is being deployed across **nine Indian airports**, enabling **contactless travel** and **biometric authentication** at key touch points. Airports like **Visakhapatnam, Ranchi, Bhubaneswar, Indore, Raipur, Bagdogra, Patna, Goa (Dabolim), and Coimbatore** are integrating **advanced digital solutions** to streamline passenger flow.

- Operational Efficiency Measures
  Indian airports are implementing **advanced airside technologies** to enhance operational efficiency and reduce emissions which includes but not limited to Adoption of Airport Collaborative Decision Making, Bridge Mounted Equipment, TaxiBots, and Eastern Cross Taxiway. These innovations are transforming Indian airports into **sustainable aviation hubs**, improving efficiency while significantly reducing environmental impact.

This State Action Plan outlines the strategic priorities and interventions required to achieve sustainable growth and resilience in 2025. The initiatives identified across infrastructure, energy, transport, and governance are designed to foster inclusive development, strengthen institutional capacity, and promote innovation. Effective implementation will depend on strong collaboration between government departments and private sector, supported by adequate resources and monitoring mechanisms.

As this plan moves forward, continuous evaluation and stakeholder engagement will be essential to ensure that the objectives are met and adjusted as necessary. By aligning state-level actions with national and global commitments, the plan seeks to deliver long-term benefits for citizens, improve quality of life, and contribute to broader sustainable development goals.

TECHNOLOGICAL ADVANCEMENTS

India's aviation sector is making significant strides in reducing emissions through a comprehensive suite of technological and operational improvements. Fleet modernization anchored by the induction of fuel-efficient aircraft like the Boeing 787, Airbus A320neo, and ATR 72-600—has already delivered substantial gains, with modern aircraft offering up to 80% greater fuel efficiency than legacy models. Engine upgrades, eco-washing techniques, and real-time performance monitoring further enhance operational efficiency and reduce emissions.

India's proactive approach—combining innovation, precision, and sustainability—positions its carriers as global leaders in aviation decarbonisation. These efforts not only align with ICAO's long-term aspirational goals but also reinforce India's commitment to equitable and effective climate action in international aviation.

India's civil aviation sector is embracing a transformative shift through the integration of Advanced Air Mobility (AAM) and Unmanned Aircraft Systems (UAS), offering scalable, low-emission alternatives to conventional transport. Electric VTOLs and drones present significant environmental advantages, including zero tailpipe emissions, reduced noise pollution, and enhanced energy efficiency, aligning with national decarbonisation goals. Operationally, these technologies bypass ground congestion, require minimal infrastructure, and enable rapid deployment in remote areas. Strategically, they bolster disaster response, border surveillance, and supply chain resilience. A phased roadmap from 2025 to 2040 outlines sandbox trials, infrastructure expansion, and full automation, supported by DGCA guidelines and industry partnerships. India's AAM blueprint is gaining global recognition as a model for sustainable, inclusive mobility.

OPERATIONAL IMPROVEMENTS

From the deployment of advanced Air Traffic Flow Management systems and Required Navigation Performance procedures to the electrification of ground fleets and adoption of fuel-saving airline practices, these measures collectively contribute to safer, more sustainable, and cost-effective operations. The integration of technologies like space-based ADS-B, TaxiBot, and smart tracking, along with data-driven flight planning and optimized aircraft handling, has resulted in measurable reductions in fuel consumption and carbon emissions.

SUSTAINABLE AVIATION FUELS AND MARKET BASED MEASURES

India is laying the foundation for large-scale deployment of Sustainable Aviation Fuel (SAF). With initial blending targets of 1% by 2027 and 5% by 2030, and feedstock availability supporting up to 33 million tonnes of SAF annually, India is well-positioned to meet future demand under high-blend scenarios. The SAF roadmap—anchored in policy reform, infrastructure development, and market incentives—aims to reduce CO_2 emissions by up to 25 million tonnes annually and establish India as a global SAF hub.

However, scaling SAF production will require overcoming cost and infrastructure challenges. Production costs remain significantly higher than conventional ATF, especially for 2G ethanol-based SAF. Strategic policy support, feedstock sustainability standards, and investment incentives will be critical to unlock India's SAF potential and position the country as a global leader in green aviation.

CORSIA represents a landmark global initiative to address emissions from international aviation through a harmonized, market-based approach. By offsetting emissions above a defined baseline, it complements other decarbonisation measures such as technological upgrades, operational improvements, and the use of Sustainable Aviation Fuels (SAF).

India, while not participating in the voluntary phase, has committed to begin offsetting obligations from 2027 onward, based on 85% of its 2019 emissions baseline. The issuance of CAR Section 10 Series C Part 1 and supporting circulars demonstrates India's proactive steps in implementing ICAO's Monitoring, Reporting, and Verification (MRV) framework. These regulations ensure transparency, compliance, and readiness for future offsetting requirements.

ASSISTANCE AND CAPACITY BUILDING

India, as a developing country and one of the fastest-growing civil aviation markets globally, holds a pivotal role in shaping the future of sustainable aviation. Its trajectory not only influences domestic connectivity and economic growth but also contributes significantly to the global aviation ecosystem.

CHAPTER 9: WAY FORWARD

Achieving long-term sustainability requires accelerated access to cleaner technologies, including:

- Low-emission aircraft and propulsion systems
- Sustainable Aviation Fuels (SAF) and advanced fuel infrastructure
- Green airport operations, including renewable energy, electric ground support equipment, and efficient terminal design.

The key component to the above goals remain as assistance and capacity building from ICAO and Member states. Few areas identified are as follows:

- Capacity Building and training programs be inclusive of all States, with additional support mechanisms (e.g., funding, translation, regional delivery) for developing countries.
- Include case-based learning, simulation exercises, and expert-led modules to build practical competencies among national authorities and operators.
- Support the development of best practice compendiums that reflect diverse regulatory contexts and operational realities.
- Encourage ICAO to establish formal platforms for peer-to-peer exchange, enabling States to share experiences, innovations, and lessons learned in implementing environmental measures.
- Support the creation of regional knowledge hubs and technical roundtables focused on specific themes such as SAF deployment, airport decarbonization, and emissions monitoring.
- Facilitate joint capacity-building initiatives, including collaborative training, expert exchanges, and co-development of tools and methodologies.