



الإستراتيجية 2040
الوطنية للطيران
NATIONAL AVIATION STRATEGY



هيئة الطيران المدني
CIVIL AVIATION AUTHORITY

Toward Protecting the Aviation Environment in the Sultanate of Oman





Introduction

Today, the civil aviation sector is considered one of the most vital industries supporting economic development and global connectivity. It facilitates links between countries and peoples while stimulating investment, trade, and tourism. However, this rapid growth is accompanied by a number of environmental challenges that require a balanced approach to ensure the sector's sustainability while safeguarding the environment and natural resources for future generations.

Amid the accelerating global drive for climate action and the achievement of the Sustainable Development Goals (SDGs), aviation environmental protection has emerged as a key pillar of the policies of the International Civil Aviation Organization (ICAO). This has been achieved through the development of standards, regulations, and initiatives aimed at reducing carbon emissions, minimizing aircraft noise, improving local air quality, and strengthening the aviation sector's resilience to the impacts of climate change.

In line with the Sultanate of Oman's commitment to supporting international efforts in environmental sustainability and its dedication to developing a modern, safe, and sustainable civil aviation sector, this publication serves as an educational and reference guide. It highlights the fundamental concepts of aviation environmental protection, the international frameworks governing this field, and the major environmental challenges associated with the civil aviation sector. It also presents the national efforts and initiatives undertaken by the Sultanate of Oman in this area.

This publication also reflects the Civil Aviation Authority's commitment to keeping pace with global developments in sustainable aviation and strengthening cooperation with local and international partners to adopt best practices and advanced technologies. These efforts contribute to building a more efficient, resilient, and sustainable aviation system capable of balancing economic growth with environmental protection.

We hope this publication will serve as a valuable knowledge resource that promotes a culture of environmental sustainability within the civil aviation sector and supports national and international efforts to build a more sustainable future for air transport.

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Terms and Abbreviations

Abbreviation	Term in English	Arabic Term
ICAO	International Civil Aviation Organization	منظمة الطيران المدني الدولي
CAEP	Committee on Aviation Environmental Protection	لجنة حماية بيئة الطيران التابعة لمنظمة الطيران المدني الدولي
Annex 16	-	الملحق السادس عشر لاتفاقية شيكاغو
SARPs	Standards and Recommended Practices	المعايير والممارسات الموصى بها
LAQ	Local Air Quality	جودة الهواء المحلي المحيط بالمطار
CORSIA	Carbon Offsetting and Reduction Scheme for International Aviation	برنامج تعويض وتخفيض الكربون من الطيران الدولي
SAF	Sustainable Aviation Fuel	وقود الطيران المستدام
LCAF	Lower Carbon Aviation Fuel	وقود الطيران منخفض الكربون
LTAG	Long-Term Aspirational Goal	الهدف الطموح الطويل الأجل لمنظمة الطيران الدولي
MRV	Monitoring, Reporting and Verification	نظام الرصد والإبلاغ والتحقق من الانبعاثات
CDO	Continuous Descent Operations	إجراءات الهبوط المستمر
CCO	Continuous Climb Operations	إجراءات الصعود المستمر
APU	Auxiliary Power Unit	وحدة الطاقة المساعدة
GSE	Ground Support Equipment	معدات الدعم الأرضي في المطار
CO ₂	Carbon Dioxide	ثاني أكسيد الكربون
CO	Carbon Monoxide	أول أكسيد الكربون
NO _x	Nitrogen Oxides	أكاسيد النيتروجين
PM	Particulate Matter	الجسيمات العالقة في الهواء
VOCs	Volatile Organic Compounds	المركبات العضوية المتطايرة
SO _x	Sulfur Oxides	أكاسيد الكبريت
SAP	State Action Plan	خطة العمل الوطنية لخفض الانبعاثات
UNFCCC	United Nations Framework Convention on Climate Change	اتفاقية الأمم المتحدة بشأن تغير المناخ



Preface

The International Civil Aviation Organization (ICAO) is a specialized agency of the United Nations responsible for regulating and developing civil aviation worldwide. It achieves this by establishing international standards and recommended practices that ensure the safety, security, efficiency, and sustainability of air transport. ICAO was established under the Convention on International Civil Aviation (Chicago Convention), signed in 1944, which serves as the primary legal framework governing international civil aviation among States. The Convention comprises nineteen technical Annexes covering a wide range of areas, including aviation safety, aviation security, air navigation, environmental protection, personnel licensing, aircraft operations, and other technical disciplines. These Annexes serve as the principal reference for States in regulating their civil aviation sectors and ensuring compliance with internationally adopted standards.

The International Civil Aviation Organization and Environmental Protection

The International Civil Aviation Organization (ICAO) places environmental protection at the core of its priorities for international civil aviation. Its environmental objectives reflect a comprehensive approach to managing and reducing the environmental impacts associated with aviation activities. ICAO works to minimize the effects of aircraft emissions on local air quality, reduce greenhouse gas emissions to help mitigate global climate change, and decrease the number of people affected by aircraft and airport operational noise. The Organization also seeks to strengthen the aviation sector's resilience to climate change by enhancing the adaptability of aviation infrastructure and improving operational efficiency. These efforts are founded on a systematic approach based on the accurate assessment of environmental impacts, the implementation of effective mitigation and adaptation measures, and the adoption of solutions that achieve a balanced integration of development objectives and environmental sustainability. Within this framework, the Member States of the International Civil Aviation Organization (ICAO), as Parties to the Chicago Convention, have agreed to focus environmental cooperation in the aviation sector on three principal areas:



Reducing greenhouse gas emissions and enhancing the air transport sector's resilience to the impacts of climate change



Reducing pollutants generated by aircraft and airport operations that are harmful to human health and the local environment.



Reducing noise generated by aircraft and airport operations.

Aviation Environmental Protection

A comprehensive framework of policies, standards, and measures aimed at minimizing the adverse impacts of civil aviation activities on the environment and human health.

Annex 16

The International Civil Aviation Organization (ICAO) developed Annex 16 to the Chicago Convention on International Civil Aviation, which establishes the Standards and Recommended Practices (SARPs) for protecting the environment from the impacts of civil aviation while maintaining the safety and efficiency of international air transport. Annex 16 is divided into four volumes, as follows:

Volume Number	Subject	Objective and Scope
Volume I	Aircraft Noise.	Establishing methodologies for measuring and classifying aircraft noise, and defining the noise standards and certification requirements that aircraft must meet during design and manufacture.
Volume II	Aircraft Engine Emissions.	Establishing engine emissions standards for air pollutants to ensure that aircraft engines comply with global environmental limits and contribute to improving local air quality.
Volume III	Aircraft Carbon Dioxide (CO ₂) Emissions.	Establishing carbon dioxide (CO ₂) emissions standards for aircraft to reduce the aviation industry's carbon footprint and contribute to climate change mitigation.
Volume IV	Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA).	Establishing the requirements for monitoring, reporting, verification (MRV), and emissions offsetting under the CORSIA scheme

ICAO continuously updates its environmental standards and guidance material to reflect the latest available science and scientific knowledge on the environmental impacts of civil aviation activities.

ICAO Committee on Aviation Environmental Protection (CAEP)

The Committee on Aviation Environmental Protection (CAEP) was established in 1983 as a technical committee reporting to the Council of the International Civil Aviation Organization (ICAO). It supports the development of environmental policies, the adoption of Standards and Recommended Practices (SARPs), and the conduct of technical studies and assessments addressing the impacts of aviation on the environment and climate.

The Committee operates through a collaborative approach involving environmental and aviation experts from around the world. It comprises 34 Members and 21 Observers, with the participation of more than 1,200 international experts representing governments, industry organizations, United Nations agencies, civil society organizations, non-governmental organizations, and research institutions. Formal Committee meetings are held every three years to review the work program and adopt future decisions, while annual Steering Group meetings monitor the progress of the technical working groups.

CAEP consists of several specialized working groups responsible for addressing specific environmental aspects of the aviation sector. Their work includes reducing aircraft noise, minimizing emissions from aircraft, airports, and flight operations, managing the Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA), and advancing the development and deployment of sustainable aviation fuels. The Committee is further supported by specialist groups in economic analysis, aircraft fleet forecasting, and environmental data management, contributing to the reduction of aviation's environmental footprint and supporting the global objective of achieving net-zero carbon emissions by 2050.





**Toward Protecting the
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Key Pillars of Aviation Environmental Protection



Key Pillars of Aviation Environmental Protection

Aircraft Noise

Aircraft noise is one of the most significant environmental and public health challenges affecting communities surrounding airports. Consequently, the International Civil Aviation Organization (ICAO) has made reducing aircraft noise and protecting affected populations a key environmental priority.

In addition to noise generated by aircraft during flight operations, other sources of airport noise may include:

- Aircraft engine ground testing.
- Auxiliary Power Units (APUs) used during ground operations.
- Other ground-based equipment, including ground power units, airport vehicles, and Ground Support Equipment (GSE).

The global aviation industry and the international community are committed to reducing aircraft noise and its impact on local communities through close cooperation among aircraft and engine manufacturers, airlines, airports, and regulatory authorities. In the 1970s, ICAO published Annex 16 – Environmental Protection, Volume I: Aircraft Noise, which established the international noise certification standards and requirements that aircraft must meet during design and manufacture. These standards are regularly reviewed and strengthened by the Committee on Aviation Environmental Protection (CAEP) in line with the latest scientific research and technological advancements, reflecting the aviation sector's ongoing commitment to improving environmental performance.

ICAO continues to study the impacts of aircraft noise and develop measures to reduce its effects while establishing clear objectives for technological innovation and monitoring global trends in population exposure to aircraft noise. At the same time, airlines, airports, and air navigation service providers work closely with local communities to reduce aircraft noise through a range of initiatives, including replacing older aircraft with quieter and more efficient models, optimizing flight paths, implementing noise-abatement departure and arrival procedures, and introducing sound insulation programs and advanced noise monitoring systems.

Balanced Approach to Aircraft Noise Management

In 2001, the International Civil Aviation Organization (ICAO) adopted the Balanced Approach to Aircraft Noise Management, providing a comprehensive framework for addressing aircraft noise on an airport-specific basis. The approach aims to achieve the greatest possible environmental benefit in the most cost-effective manner, using objective and measurable criteria.

S	Elements	Examples
1	Noise Reduction at Source	Developing quieter aircraft by improving engine technology and aircraft design
2	Land-Use Planning and Management	Implementing land-use planning and management measures by designating appropriate areas for residential development and other activities near airports to minimize community noise exposure
3	Noise Abatement Operational Procedures	Applying noise abatement operational procedures through optimized departure and arrival routes
4	Operating Restrictions	Implementing operating restrictions



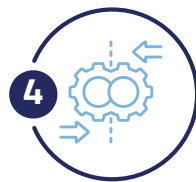
**Noise Reduction
at Source**



**Land Use
Planning and
Management**



**Noise Abatement
Operational
Procedures**



**Operating
Restrictions**

► Steps for Implementing the Balanced Approach to Noise Management:

- | | | | | | |
|----|---|----|---|----|--|
| 01 | Assess the airport noise situation. | 02 | Identify potential noise mitigation measures. | 03 | Provide public notification of the adopted measures. |
| 04 | Define the desired environmental objective. | 05 | Conduct a cost–benefit analysis. | 06 | Implement the selected measures. |
| 07 | Consult with relevant stakeholders. | 08 | Select the most cost-effective measures. | 09 | Establish a mechanism for dispute resolution. |

Local Air Quality

The International Civil Aviation Organization has identified Local Air Quality (LAQ) as one of its key environmental objectives. It works to reduce the harmful impacts of emissions generated by aviation activities in order to protect human health and safeguard the environment.

Air Pollution

Air pollution refers to the presence of contaminants in the atmosphere that degrade air quality and pose risks to human health and safety. The principal pollutants associated with aviation activities include:

No	Pollutants	Primary Source
1	Carbon Dioxide (CO ₂)	Combustion of hydrocarbon fuels.
2	Carbon Monoxide (CO)	Incomplete combustion of fuel.
3	Nitrogen Oxides (NO _x)	Formed at high temperatures and pressures in aircraft and vehicle engines.
4	Volatile Organic Compounds (VOCs)	Chemical substances emitted from fuel tanks and lubricating oils.
5	Particulate Matter (PM)	Solid or liquid particles suspended in the air, generated from fuel combustion, tire and brake wear, and pavement deterioration.
6	Sulfur Oxides (SO _x)	Produced during fuel combustion.

► **Air pollutants at airports are generated from a variety of sources, the most significant of which include:**

■ **Aircraft:**

- Main engines and Auxiliary Power Units (APUs) are the primary sources of gaseous emissions.
- Particulate matter is generated from aircraft engines, APUs, as well as brake and tire wear.

■ **Ground Support Equipment (GSE)**

Includes refueling vehicles, baggage handling vehicles, catering trucks, and passenger boarding stairs.

■ **Infrastructure and Stationary Sources**

Includes incinerators, heating, ventilation and air conditioning (HVAC) plants, firefighting training activities, construction works, and wastewater treatment facilities.

■ **Landside Access Traffic**

Passenger and freight transportation to and from the airport.

Environmental Measures for Managing Local Air Quality:

The International Civil Aviation Organization is committed to strengthening efforts to reduce the impact of aviation emissions on local air quality by developing international standards, guidance material, and supporting technical documents. These enable Member States to implement effective and sustainable solutions while ensuring an environmentally sustainable future for international aviation.

Annex 16, Volume II contains the Standards and Recommended Practices (SARPs) for the environmental certification of aircraft engine emissions. These standards are intended to address the potential impacts of aircraft engine pollutants on local air quality, with particular emphasis on protecting human health.

Most States rely on national or regional ambient air quality standards based on the guidelines of the World Health Organization and develop their air quality management plans through the following measures:

- Measuring pollutant concentrations at ground level.
- Assessing compliance with applicable air quality standards.
- Identifying emission sources and evaluating their impact on local air quality.
- Preparing emission inventories and developing dispersion models to estimate pollutant distribution.
- Prioritizing the most significant emission sources for mitigation actions.

Mitigation measures and operational practices may include:

- Optimizing runway and taxiway layouts to reduce aircraft engine operating time.
- Using fixed electrical ground power at aircraft stands instead of operating Auxiliary Power Units (APUs).
- Conducting engine testing in enclosed facilities equipped with filtration systems and catalytic converters to reduce emissions.
- Transitioning to clean or electric vehicles for ground operations.
- Performing regular maintenance.
- Upgrading equipment and improving energy efficiency.
- Enhancing public transportation, rail connectivity, and terminal design to reduce emissions and lower operating costs

Climate Change

The International Civil Aviation Organization is committed to supporting the achievement of the Paris Agreement objective of limiting the increase in global average temperature to well below 2 °C. International civil aviation accounts for approximately 2% of global carbon dioxide (CO₂) emissions resulting from human activities.

In support of this commitment, ICAO adopted the Long-Term Aspirational Goal (LTAG) to reduce the adverse impacts of international civil aviation on the global climate by achieving net-zero carbon emissions from international civil aviation by 2050.

To achieve the Long-Term Aspirational Goal (LTAG), ICAO has established a Basket of Measures, comprising a range of mitigation actions that can be implemented to achieve the targeted objective, including:



Implementation of market-based measures, such as the Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA), to reduce carbon emissions from international aviation.



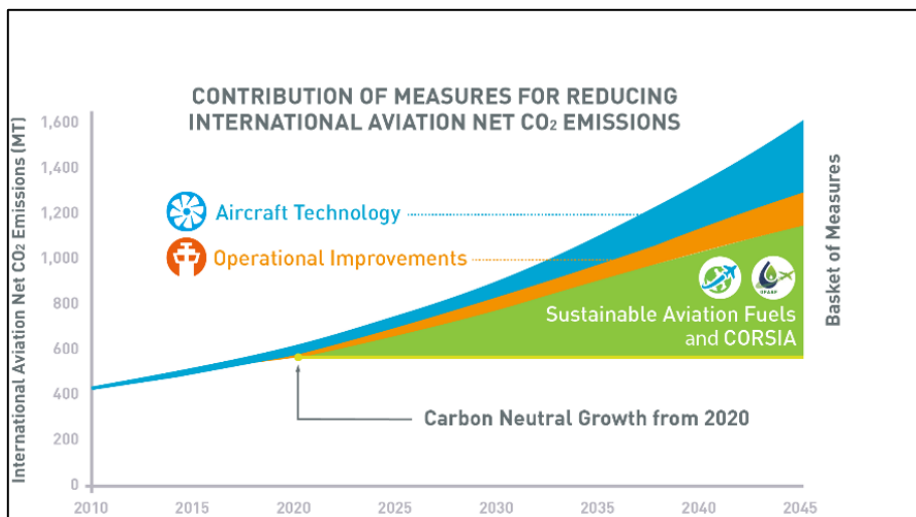
Promoting the use of Sustainable Aviation Fuel (SAF) and Lower Carbon Aviation Fuel (LCAF) to reduce greenhouse gas emissions from international aviation.



Developing operational procedures for air traffic management, aircraft, and airports in a more environmentally efficient manner.



Improving aircraft technology to reduce emissions.



Mitigation Measures

► Improving Aircraft Technology to Reduce Emissions

Technological advancements are among the most effective means of enhancing aircraft efficiency and reducing fuel consumption, thereby directly lowering aviation's environmental impact. These improvements encompass a range of measures implemented over the medium, long, and long-term horizons. They focus on upgrading existing aircraft, modernizing future fleets, and adopting innovative technologies capable of delivering transformative changes to the aviation industry.

■ Improving the Efficiency of Existing Aircraft (Medium Term):

- Retrofitting aircraft with more efficient technologies.
- Introducing incremental upgrades to aircraft systems and components.
- Reducing fuel consumption and improving operational performance.

■ Fleet Modernization (Long Term):

- Replacing older aircraft with newer, more fuel-efficient models.
- Developing innovative engine designs.
- Enhancing aircraft structures to comply with stringent environmental standards.

■ Future Technologies (very long term):

- Adopting breakthrough aircraft design technologies.
- Achieving significant reductions in greenhouse gas emissions.

Key Challenges Associated with These Improvements:

- The need for substantial financial investment.
- The long timeframes required before tangible results can be realized.

Enhancing Operational Procedures for Air Traffic Management, Aircraft, and Airports

Operational improvements represent one of the most effective and rapidly implementable measures for reducing aviation emissions. They focus on optimizing aircraft operations and air traffic management without requiring significant investment in new equipment. The scope of operational improvements encompasses all activities associated with flight operations, from pre-flight planning through to flight completion, including air traffic management and airport ground operations.

■ Improving Flight Efficiency

- Selecting the optimum aircraft speed and altitude based on flight conditions (e.g., aircraft weight, wind, and temperature).
- Optimizing flight routes to minimize the distance flown.
- Integrating communication, navigation, surveillance, and air traffic management (CNS/ATM) systems while employing the most advanced available technologies.
- Implementing fuel-efficient flight procedures, including:
 - Continuous Climb Operations (CCO).
 - Continuous Descent Operations (CDO).

Continuous Climb Operations (CCO)

A flight procedure in which an aircraft climbs continuously and smoothly from takeoff to its cruising altitude without level-offs at intermediate altitudes, thereby reducing fuel consumption and emissions.

Continuous Descent Operations (CDO)

A flight procedure in which an aircraft descends continuously and progressively from cruising altitude to landing without level flight at intermediate altitudes, resulting in lower fuel consumption, reduced emissions, and decreased noise.

■ Aircraft Operations

- Reducing aircraft weight to improve fuel efficiency.
- Minimizing the use of reverse thrust and Auxiliary Power Units (APUs) whenever operationally feasible.
- Using fewer engines during taxiing (e.g., single-engine taxi operations where appropriate)
- Selecting the most suitable aircraft for the mission to maximize operational and fuel efficiency.

■ Airports Infrastructure Development

- Optimizing the design of runways and taxiways to reduce aircraft taxiing time and alleviate ground congestion.
- Utilizing renewable energy sources, such as solar and wind power, to operate airport facilities.
- Upgrading airport buildings to improve energy efficiency, particularly in cooling and lighting systems.
- Providing ground power units (GPUs) for aircraft to minimize engine operation while parked at the gate.
- Transitioning ground support vehicles to clean energy or alternative fuels.
- Improving access to and from the airport by promoting public transportation and reducing reliance on private vehicles.

Enhancing the Use of Sustainable Aviation Fuel (SAF) and Lower Carbon Aviation Fuel (LCAF)

Sustainable Aviation Fuel (SAF) is considered one of the key pillars for reducing the largest share of emissions in the aviation sector (approximately 55–65%). It is produced from renewable and diverse feedstocks, including vegetable oils, animal fats, municipal waste, as well as advanced processes that convert biomass or utilize hydrogen and captured carbon dioxide.

SAF is characterized by several features that make it a practical and viable option, including:

- Achieving significant reductions in greenhouse gas emissions over its life cycle compared to conventional jet fuel.
- Being usable either as a drop-in fuel or blended with conventional jet fuel without requiring major modifications to aircraft or engines.
- Compatibility with existing airport infrastructure and fueling systems, facilitating its gradual adoption.

Despite these advantages, the widespread adoption of Sustainable Aviation Fuel (SAF) continues to face several key challenges, including:

- Limited global production capacity compared to rapidly growing demand.
- Higher production costs relative to conventional fossil-based jet fuel.
- The need to develop efficient and sustainable supply chains.

In addition to SAF, Lower Carbon Aviation Fuel (LCAF) emerges as a complementary option that contributes to emissions reduction. It is based on improving conventional fuel production processes through technologies that reduce carbon intensity, such as carbon capture or the use of cleaner energy sources in refining operations. This type of fuel is considered a transitional solution that can be implemented in the near term to support broader decarbonization efforts in the aviation sector.

Sustainable Aviation Fuel (SAF)

Aviation fuel derived from renewable sources or waste materials that meets sustainability criteria.

Lower Carbon Aviation Fuel (LCAF)

Lower Carbon Aviation Fuel (LCAF) is fossil-based aviation fuel produced using technologies that reduce greenhouse gas emissions over its life cycle by at least 10% compared to conventional jet fuel.

In addition, other low-carbon future alternatives include:

- **Hydrogen**, which is expected to bring a transformative shift in aircraft design and operations, particularly for short- and medium-haul flights.
- **Electric aircraft**, which rely on batteries and represent a promising option for short-range operations, despite challenges related to energy density.

Despite their significant potential, these alternatives face common challenges, including:

- The need for substantial investment in research and development.
- The development of integrated infrastructure for production, storage, and distribution.
- Establishing supportive regulatory and legislative frameworks to accelerate the adoption of these technologies.

Adoption of Market-Based Measures, such as CORSIA, to Reduce Emissions at the International Level

The International Civil Aviation Organization (ICAO) has launched the Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA), which is the first global market-based mechanism aimed at addressing CO₂ emissions from international aviation. The scheme seeks to achieve carbon-neutral growth from 2020 onwards by requiring airlines to offset the increase in emissions resulting from the growth of international air traffic.

The implementation of the scheme follows a phased approach, starting with a pilot and voluntary phase (2021–2023), followed by the first phase (2024–2026), and then the mandatory phase beginning in 2027, covering most states with significant aviation activity. Some developing countries and states with limited aviation activity are exempt, in recognition of their economic and operational capacities.

The program is based on a robust Monitoring, Reporting, and Verification (MRV) system, under which airlines are required to measure their emissions annually according to standardized methodologies and submit verified reports reviewed by independent bodies to ensure transparency and accuracy.

Airlines are allowed to purchase carbon offset units from certified environmental projects, such as renewable energy initiatives, reforestation projects, and energy efficiency improvements. These projects help reduce or remove emissions in other sectors, thereby compensating for aviation-related emissions.

CORSIA operates in synergy with other measures, including the development of advanced aircraft technologies, improved operational efficiency, and the use of Sustainable Aviation Fuel (SAF), thereby enhancing the effectiveness of global efforts to achieve environmental sustainability goals and reduce the long-term environmental impact of the aviation sector.

CORSIA (Carbon Offsetting and Reduction Scheme for International Aviation)

CORSIA is a global market-based measure introduced by the International Civil Aviation Organization (ICAO) to offset and reduce carbon emissions from international aviation. It requires airlines to balance the growth of their emissions by purchasing carbon credits or using approved emission reduction mechanisms.



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(State Action Plans)



(State Action Plans)

A national strategy, future emissions scenarios, mitigation measures.

ICAO launched the State Action Plan on CO₂ Emissions Reduction in 2010 to enable member states to develop a long-term strategy on climate change in the international aviation sector. It includes a comprehensive assessment of current and future emission levels and sets quantitative and qualitative targets to reduce these emissions in the short, **medium, and long term through:**

- 01 **Baseline definition:** estimating emissions without implementing any mitigation actions.
- 02 **Measure selection:** identifying appropriate emission reduction actions in line with ICAO mitigation measures (e.g., fleet modernization, improved air traffic management efficiency, and the use of Sustainable and Lower Carbon Aviation Fuels, among others).
- 03 **Impact assessment:** estimating the expected CO₂ reduction resulting from the implementation of selected measures.
- 04 **Support needs identification:** reporting technical, financial, or training requirements necessary to implement the measures.

The State Action Plan is a strategic tool that enables ICAO to monitor progress toward achieving the long-term global aspirational goal. States are required to update their plans every three years.



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Climate Change Adaptation



Climate Change Adaptation

Expected impacts, adaptation measures

Climate change is increasingly affecting the global aviation sector, as rising temperatures, changing precipitation patterns, and the increasing frequency and intensity of storms pose risks to aviation infrastructure, operational processes, safety, and business continuity. The following outlines some phenomena, **their impacts on air traffic operations, and associated adaptation measures to address them:**

Climate Phenomenon	Expected Impact	Adaptation Measures
Rising Temperatures	■ Reduced aircraft performance due to lower air density and increased takeoff requirements. ■ Increased strain on cooling systems in airports and aircraft. ■ Degradation of runway surfaces and higher risks of thermal stress.	■ Enhancing cooling and ventilation systems. ■ Using heat-resistant materials in infrastructure. ■ Regular strengthening and maintenance of runways. ■ Adjusting flight schedules.
Desertification and Sandstorms	■ Reduced visibility leading to flight delays or cancellations. ■ Runway erosion and damage to engines and ground equipment. ■ Increased operational and maintenance costs.	■ Constructing windbreaks to reduce dust. ■ Using drought-resistant vegetation with low water consumption. ■ Using recycled water for landscaping. ■ Conducting regular maintenance of infrastructure.
Storms, Floods, and Hurricanes	■ Damage or destruction of infrastructure and flooding of drainage systems. ■ Delays and cancellations, reduced operational capacity, and occasional runway closures, leading to higher operational costs. ■ Impacts on ground transportation to and from the airport. ■ Increased maintenance requirements.	■ Designing or upgrading facilities to ensure resilience to extreme weather events such as hurricanes and floods. ■ Improving weather forecasting and understanding of meteorological phenomena before they occur. ■ Preparing for storms by securing equipment, checking lighting and navigation systems, storing fuel for backup generators, and removing debris. ■ Developing more efficient drainage systems. ■ Implementing flexible operational plans during severe weather conditions.
Impact on Biodiversity	■ Changes in ecosystems lead to shifts in migration patterns and the distribution of birds and wildlife around airports. ■ Increased risk of bird strikes due to changes in behavior or population growth. ■ Loss of natural habitats may cause wildlife to concentrate in airport areas. ■ Spread of invasive species and changes in vegetation cover, which may increase operational risks and maintenance costs.	■ Understanding the impact of climate change on birds and animals to assess risks and develop adaptation plans. ■ Continuous monitoring of wildlife and vegetation within and around airports. ■ Implementing wildlife hazard management systems. ■ Managing vegetation cover to reduce attraction of birds and animals. ■ Collaborating with environmental experts to ensure a balance between safety and biodiversity conservation.
Sea level rise	■ Flooding of airport infrastructure in low-lying coastal airports, including runways, navigation, and communication systems. ■ Damage to facilities due to saltwater intrusion and rising groundwater levels.	■ Construction of coastal barriers and shoreline protection structures in vulnerable areas. ■ Improving drainage systems. ■ Integrating sea level rise projections into planning and design processes





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Airports and associated environmental issues



Airports and associated environmental issues

Environmental management and international efforts

Airports play a vital role in enhancing global connectivity and supporting economic growth, while simultaneously facing increasing pressure to address the environmental impacts of the aviation sector. Environmental management at airports is a fundamental component in ensuring the sustainability of aviation by reducing impacts associated with noise, emissions, water and waste management, energy consumption, and other operational aspects. This relies on integrated planning and the application of best practices that ensure environmental compliance while improving operational efficiency and sustainability.

In 2021, the Airports Council International (ACI World) led the development of the long-term carbon reduction goal for the airport sector, aiming to achieve net-zero carbon emissions by 2050 as a unified step toward advancing climate action in aviation. Although airports contribute a relatively small share of total aviation emissions, they remain a key enabler in supporting decarbonization efforts, climate change adaptation, and the adoption of sustainable solutions that balance growth requirements with environmental and community protection.

The International Civil Aviation Organization has also focused on the environmental aspects of airports and their operations. It has developed practices and standards to reduce environmental impacts resulting from operational activities and has implemented a platform for sharing best practices for green airports, including:



Smart buildings and
renewable energy



Green mobility



Climate change
resilience



Biodiversity protection



Community engagement



Sustainability reporting

Countries need to develop both regulatory and voluntary policies and procedures to ensure that airports are aligned with their surrounding environment and to achieve a balanced approach to managing various environmental issues associated with airport and aircraft operations on the surrounding environment, such as:

	Water management		Land use
	Climate change (mitigation & adaptation)		Soil pollution
	Noise		Waste management
	Air quality		Biodiversity management



The background of the entire page is an aerial photograph of a vast, dense layer of white clouds. A large, solid blue diagonal shape cuts across the image from the top-left corner towards the bottom-right, creating a modern, geometric design.

Toward Protecting the Aviation Environment in the Sultanate of Oman

Sultanate of Oman and Aviation Environmental Protection



Sultanate of Oman and Aviation Environmental Protection

Institutional Frameworks, Objectives, National Efforts, and Achievements

The civil aviation sector in the Sultanate of Oman is considered one of the key pillars of the national economy and social development. The sector has witnessed a significant increase in air traffic and is expected to grow further in the coming years. Although the growth in air traffic is an economic necessity, the resulting environmental impacts require the implementation of a range of measures and actions to mitigate them.

In this context, the Civil Aviation Authority has been committed to strengthening efforts to reduce the environmental impacts of both domestic and international civil aviation activities, reaffirming its commitment to developing a modern and sustainable aviation sector. This aligns with Oman Vision 2040, the national net-zero emissions target by 2050, and the Long-Term Aspirational Goal (LTAG) of the International Civil Aviation Organization.

Domestic aviation	International aviation
Domestic flights are flights operating within the boundaries of a single country (from one city to another). Example: Muscat to Salalah.	International flights are cross-border flights operating between two or more countries. Example: Muscat to Paris.
They are subject to national laws and local regulations, as well as international standards derived from the United Nations Framework Convention on Climate Change (UNFCCC).	They are governed by international agreements and standards, including those of the International Civil Aviation Organization, as well as national laws derived from them.
They contribute to achieving the national net-zero emissions target.	They contribute to achieving the Long-Term Aspirational Goal (LTAG) of the International Civil Aviation Organization.

Administrative Divisions for Aviation

In 2016, the Civil Aviation Authority established a dedicated Aviation Environmental Protection Section responsible for monitoring the implementation of obligations related to environmental protection in civil aviation. The section also contributes to the development of environmental policies and regulations for the sector, in addition to collecting and analyzing environmental statistics in accordance with applicable requirements.

In response to growing global attention and rapid developments in this field, a Department of Aviation Environmental Protection was established in 2026 with **the following responsibilities:**

- Contributing to the fulfillment of local, regional, and international obligations related to the protection of the civil aviation environment.

- Participating in the development of Oman's environmental policy and achieving national net-zero emissions targets in areas related to civil aviation activities, in coordination with relevant authorities.
- Monitoring developments and updates in civil aviation environmental protection at local, regional, and international levels, and strengthening cooperation with specialized organizations and institutions.
- Developing and updating environmental protection systems for civil aviation activities in accordance with national laws and international conventions ratified by the Sultanate of Oman.
- Monitoring and assessing the negative environmental impacts of civil aviation activities and airports, and contributing to mitigation proposals and initiatives in cooperation with relevant stakeholders.
- Preparing and updating the national action plan for reducing carbon dioxide emissions from international civil aviation activities.
- Following up on the implementation of local and international environmental programs aimed at reducing emissions from civil aviation, such as the Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA) and the Carbon Accreditation Program.
- Participating in local, regional, and international conferences, and representing the Sultanate of Oman in negotiations and agreements related to aviation environmental protection.
- Contributing to the development of research, innovation, and knowledge exchange in the field of aviation environmental protection.
- Conducting field visits to relevant entities to support the implementation of aviation environmental protection responsibilities.
- Raising awareness and promoting environmental protection concepts among all segments of society, while reinforcing environmental conservation principles in line with sustainable development goals and Oman Vision 2040.
- Contributing to the establishment and updating of a database of indicators related to air quality, noise, and emissions from civil aviation activities and airports.

Civil Aviation Law and Its Executive Regulations

In accordance with the Civil Aviation Law issued by Royal Decree No. 62/2023 and its Executive Regulations No. 116/2023, the Civil Aviation Authority is empowered to issue regulations related to the protection of the environment from the impacts of civil aviation activities, in line with international standards and applicable legislation in the Sultanate of Oman. This is carried out in coordination with relevant stakeholders, where the Authority develops guidelines and regulatory systems to ensure the achievement of its environmental objectives in alignment with national and international commitments.

National Aviation Environmental Protection

At the institutional level, a National Aviation Environmental Protection Committee has been established under the chairmanship of the Director General of Civil Aviation Regulation, with membership including the Ministry of Energy and Minerals, the Environment Authority, as well as relevant stakeholders such as air operators and Oman Airports. This committee is responsible for overseeing the implementation of the responsibilities and obligations set out in the Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA) and the reduction of carbon dioxide emissions in international aviation. It also undertakes the review and assessment of policies and resolutions related to aviation environmental protection issued by the International Civil Aviation Organization, while closely monitoring the Sultanate of Oman's compliance with the implementation of these international requirements and standards, ensuring alignment with global best practices and national environmental objectives.

National Action Plan

In line with the Sultanate of Oman's commitment to achieving net-zero emissions by 2050 and in implementation of its international obligations in the field of aviation environmental protection, Oman has submitted its State Action Plan for the reduction of carbon dioxide emissions from international civil aviation to the International Civil Aviation Organization. The plan outlines the projected future growth of air traffic in the Sultanate, as well as the expected levels of emissions from international civil aviation up to the year 2050. It also identifies a range of mitigation measures that can be implemented to reduce emissions, based on ICAO's basket of measures, which includes technological improvements, operational enhancements, and market-based mechanisms such as CORSIA.

The Sultanate of Oman continues to periodically update this plan in close cooperation with relevant national and international stakeholders to ensure alignment with global best practices and to strengthen the long-term trajectory toward emissions reduction and climate objectives.

International and Regional Participation

The Sultanate of Oman actively participates in international efforts led by ICAO to enhance the sustainability of the aviation sector. This includes attendance at international meetings, submission of working papers, and exchange of expertise and knowledge in sustainable aviation technologies. In 2024, Oman joined the ICAO Committee on Aviation Environmental Protection (CAEP), reaffirming its commitment to playing an active and influential role in global environmental initiatives in aviation.

Oman is also a member of the environmental committee of the Arab Civil Aviation Organization, which follows up on the implementation of ICAO commitments and decisions across Arab states, ensuring their adaptation to national circumstances.

Aviation Environmental Protection Projects

The Aviation Environmental Protection Department is implementing a number of projects aimed at strengthening environmental sustainability in the aviation sector. These include initiatives focused on reducing emissions from the aviation industry and studying the most effective mitigation options at both national and international levels from environmental and economic perspectives. The projects also cover the development of aircraft and airport noise management mechanisms, the enhancement of local air quality in relation to aviation activities, and the strengthening of the aviation sector's resilience and adaptation to the adverse impacts of climate change. In addition, the department works on the development and issuance of regulations and legislative frameworks related to aviation environmental protection, along with other related sustainability initiatives.

Efforts to Reduce Emissions from the Aviation Sector in the Sultanate of Oman

The Sultanate of Oman adopts an integrated approach to enhancing the sustainability of the aviation sector, based on four key pillars: technological advancement, operational efficiency improvements, expanded use of Sustainable Aviation Fuel (SAF) and Lower Carbon Aviation Fuel (LCAF), and compliance with international market-based mechanisms. This approach reflects Oman's commitment to implementing global best practices to achieve a balance between economic growth and environmental protection.

■ Advancing Aircraft Technology to Reduce Emissions

National airlines continue to modernize their aircraft fleets through phased renewal programs by replacing older aircraft with new-generation models that offer greater fuel efficiency, lightweight materials, and more advanced engines. This approach contributes to improved operational performance and lower carbon emissions, while supporting Oman's national sustainability objectives.

■ Enhancing Operational Efficiency in Air Traffic Management, Aircraft Operations, and Airports

Operational efficiency represents a fundamental pillar of emissions reduction. A range of internationally recognized operational measures has been implemented to improve fuel efficiency without requiring significant capital investment. These measures include optimizing take-off and landing procedures, applying single-engine taxiing after landing, and other fuel-saving operational practices.

Air traffic management systems have also undergone significant modernization through the introduction of advanced communication, navigation, and surveillance technologies. These developments have enhanced air traffic flow, improved the efficient use of Omani airspace, generated fuel savings, and reduced greenhouse gas emissions.

A flagship initiative in this regard is the "Ajwaa" Project, one of the Sultanate's strategic aviation projects aimed at modernizing Omani airspace by ensuring the highest standards of safety, security, and environmental protection. The project also enhances the integration of air routes and air navigation systems with neighboring countries while improving the efficiency of air navigation services. These improvements support more efficient flight operations, reduce flight times and fuel consumption, and consequently lower carbon emissions.

■ **Promoting the Use of Sustainable Aviation Fuel (SAF) and Lower Carbon Aviation Fuel (LCAF)**

The Sultanate of Oman is giving increasing priority to the development and use of Sustainable Aviation Fuel (SAF) and Lower Carbon Aviation Fuel (LCAF) by exploring national opportunities for their production and utilization, while assessing the challenges and policy measures required to support this transition. To raise awareness and promote innovation in this field, the Civil Aviation Authority organized the Sustainable Aviation Fuel, Lower Carbon Aviation Fuel, and Clean Energy Innovation Support Forum in 2023 under the theme "Clean Fuel for Sustainable Aviation." The forum brought together senior government officials, international experts, and representatives of leading international organizations and companies. It aimed to support the development of SAF and LCAF, strengthen their role in reducing the environmental footprint of aviation, align with Oman Vision 2040 and international commitments, and explore investment opportunities in this emerging sector.

In 2024, the Civil Aviation Authority established a National Sustainable Aviation Fuel and Lower Carbon Aviation Fuel Working Group, comprising representatives from relevant government entities, airlines, airports, the Ministry of Energy and Minerals, fuel producers, academic institutions, and research centers. The Working Group aims to develop an integrated national framework for this sector through the preparation of a national policy, the promotion of public-private partnerships, market analysis, identification of investment opportunities, enhancement of airport readiness for sustainable fuel deployment, assessment of economic and social impacts, and support for research, development, and national capacity building. As part of its mandate, the Group is conducting the necessary studies and research to explore opportunities for developing a sustainable and lower-carbon aviation fuel industry in the Sultanate of Oman. Several companies in the Sultanate are currently developing Sustainable Aviation Fuel using a variety of production pathways, including waste-derived feedstocks, organic materials, selected energy crops, hydrogen, captured carbon dioxide, and other innovative technologies. Oman Vision 2040 and the National Net Zero 2050 Plan provide a strong foundation for advancing renewable energy and green hydrogen, thereby creating favorable conditions for the development of SAF and LCAF and positioning the Sultanate as a potential future supplier of clean energy solutions for the global aviation sector.

However, this sector faces a number of challenges, the most significant of which include:

- The availability of feedstocks such as hydrogen and biogenic carbon dioxide.
- High production and operating costs.
- Airport infrastructure readiness.
- Demand for sustainable aviation fuel.
- National and international regulatory frameworks.
- Limited global regulatory harmonization.
- Import and supply chain challenges. Technology readiness.
- Price volatility and the associated economic and social impacts.

Lower Carbon Aviation Fuel (LCAF) represents a more practical, realistic, and readily deployable option for reducing aviation emissions in the Sultanate of Oman in the near term, given that Oman is an oil-producing country with established refining capacity. However, its deployment requires advanced environmental life-cycle assessment studies and the development of effective mechanisms to reduce carbon intensity, while addressing challenges such as high implementation costs and the need for specialized technical expertise.

Implementing Market-Based Measures, such as CORSIA, to Reduce International Aviation Emissions

The Sultanate of Oman, together with the other Member States of the International Civil Aviation Organization, adopted the resolution establishing Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA) during the 39th Session of the ICAO Assembly in 2016. Oman was among the countries that formally expressed, in June 2017, its intention to participate voluntarily in CORSIA from the Pilot Phase onwards.

The Civil Aviation Authority has coordinated with the Sultanate's international air operators, namely Oman Air and SalamAir, to ensure compliance with all operational and reporting requirements of the CORSIA scheme. The Civil Aviation Authority has also issued national legislation implementing CORSIA, requiring national airlines to monitor and report carbon dioxide (CO₂) emissions from international flights, in addition to purchasing eligible carbon offset units in accordance with ICAO requirements.

The Civil Aviation Authority is also working to maximize the national environmental and economic benefits of implementing CORSIA by coordinating with the relevant authorities to facilitate the development of national projects capable of generating carbon credits. This approach enhances environmental and economic benefits at the national level while strengthening the Sultanate of Oman's participation in international carbon markets and creating added value through nationally developed carbon mitigation projects.

Airports

Oman Airports is committed to a comprehensive environmental policy aimed at minimizing the environmental impacts arising from its operational activities and services, in line with the Sultanate of Oman's commitment to achieving net-zero emissions. This policy is based on environmentally responsible operations, compliance with environmental legislation and regulations, and the continuous improvement of environmental performance through regular monitoring, target setting, and performance measurement. It also includes preventing or minimizing impacts on air, water, and soil, ensuring efficient waste management, establishing controls for activities with significant environmental impacts, preparing and implementing a carbon management and emissions reduction plan, integrating environmental considerations into decision-making processes, promoting environmental awareness among employees and stakeholders, and continuously enhancing the environmental management system to ensure sustainability and ongoing environmental performance improvement.

The Civil Aviation Authority is committed to monitoring the environmental performance of airports through regular airport inspections, follow-up reports, and periodic meetings with relevant specialists. It also continues to strengthen the legislative and regulatory frameworks governing the management of environmental issues at airports in coordination with the relevant authorities.



Conclusion



Aviation environmental protection is no longer an optional consideration; it has become a shared responsibility and one of the fundamental pillars for ensuring the long-term sustainability of the global civil aviation sector.

The Civil Aviation Authority will continue to work closely with its local, regional, and international partners to keep pace with global developments and adopt best practices and innovative solutions that contribute to minimizing the environmental impacts of aviation. Through these efforts, the Authority aims to strengthen the role of the aviation sector as a driver of sustainable economic and social development while achieving an appropriate balance between the demands of growth and the protection of the environment for future generations.



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