MINISTRY OF TRANSPORT
MALAYSIA

Malaysia Aviation Decarbonisation Blueprint

Published by:

MINISTRY OF TRANSPORT MALAYSIA

No. 26, Jalan Tun Hussein, Presint 4, 62100 W.P. Putrajaya, Malaysia

T. 03 8000 8000 | F. 03 8888 0158 | HL. 1800 88 7723

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Foreword by **HON. MINISTER OF TRANSPORT OF MALAYSIA**

The Long-Term Aspirational Goal (LTAG) of achieving net zero carbon emissions by 2050 was introduced and adopted during the 41st ICAO Assembly session in 2022. The aim was to decarbonise the international aviation sector, in line with the Paris Agreement that was adopted at the 21st session of the Conference of the Parties (COP21) to the United Nations Framework Convention on Climate Change (UNFCCC).

As an ICAO Member State, Malaysia actively supports the ICAO Global Framework and recognizes the need to accelerate progress in sustainable aviation. In the pursuit of achieving net zero carbon emission by 2050, Malaysia published its National Energy Transition Roadmap (NETR) in August 2023, which laid the groundwork for Malaysia's sustainable growth agenda.

On this ground, Malaysia is committed to developing its sustainable aviation blueprint known as Malaysia Aviation Decarbonisation Blueprint (MADB). This blueprint outlines a comprehensive strategy for decarbonising the Malaysian aviation sector including providing a clear pathway for achieving net zero emissions by 2050 in order to ensure the sector can grow sustainably.

The MADB connects ongoing initiatives by individual stakeholders and the Civil Aviation Authority of Malaysia (CAAM) and brings together multiple parties through consultative meetings and industry-led task forces. The blueprint also identifies opportunities for collaboration among various ministries and government agencies to cultivate the necessary ecosystem for Malaysia to fulfil its aviation environmental commitments while advancing national green economy aspirations. Regular assessments and revisions will ensure that the MADB remains aligned with global best practices and continues to guide the Malaysian aviation sector towards sustainable and environmentally responsible practices.

As we embark on this journey, let us deepen our collaboration and cooperate to spearhead the initiatives towards net zero carbon emission by 2050 and accelerate smoothly the sustainable growth of the aviation industry in Malaysia.

LOKE SIEW FOOK

5 September 2024

1 Executive **Summary**

The air travel industry is one of the most important sectors of the Malaysian economy. The Malaysian aviation sector has experienced significant growth over the past decade, becoming a crucial component of the country's economy. However, this growth has brought about substantial challenges, particularly in decarbonisation. The sector faces the dual challenge of accommodating increased demand while reducing its carbon footprint to align with global sustainability goals.

This blueprint outlines a comprehensive strategy for decarbonising the Malaysian aviation sector. It provides a clear pathway for achieving net-zero emissions by 2050, ensuring that the sector can grow sustainably.

To chart the country's progress, Malaysia has reported carbon reduction initiatives and forecasts from international aviation activities through the State Action Plan (SAP) since 2013. Malaysia's commitments have been strengthened with each SAP submission, with the latest being SAP 3 which was submitted in 2022.

In accordance with the International Civil Aviation Organisation's (ICAO) recommended basket of measures, Malaysia outlined four (4) key initiatives to cap carbon emission growth, namely:

a) Aircraft Technologies

b) Operational Improvements

c) Sustainable Aviation Fuel (SAF)

d) Market-Based Measures (MBM) - i.e. CORSIA

In August 2023, Malaysia published its National Energy Transition Roadmap (NETR), which identified one of the country's green energy transition strategies to include positioning Malaysia as a regional Sustainable Aviation Fuel (SAF) producer through developing the country's array of feedstock. The NETR projected the contribution of SAF to reach as high as 71% of carbon emissions reduction by 2050.

In the same year, the ICAO Global Framework for SAF, Lower Carbon Aviation Fuel (LCAF) and other Aviation Cleaner Energies was also adopted during the Third Conference on Aviation and Alternative Fuels (CAAF/3) in November 2023. The ICAO Global Framework calls for a collective global vision to reduce carbon dioxide (CO2) emissions in international aviation by up to 5% by 2030 through the use of SAF, LCAF, and other aviation cleaner energies.

As an ICAO Member State, Malaysia supports the ICAO Global Framework and appreciates the need to step up progress on developing its own SAF supply, not only for local consumption but also to meet global demand. This support could include a national policy to require SAF utilisation on all flights to expedite the achievement of ICAO's Long-Term Aspirational Goals (LTAG).

Thus, other than periodically reviewing and updating the country's commitments in its SAP, Malaysia is publishing its national decarbonisation roadmap as an extrapolation of its SAP commitments to incorporate longer-term measures and policy priorities that are required for the Malaysian aviation sector to arrive at its LTAG. The Malaysia Aviation Decarbonisation Blueprint (MADB) connects ongoing initiatives by the individual stakeholders and the Civil Aviation Authority of Malaysia (CAAM), and brings together multiple parties through consultative meetings and industry-led task forces (Sections 6-8). The blueprint also identifies opportunities for collaboration among various ministries and government agencies to cultivate the necessary ecosystem for Malaysia to fulfil its aviation environmental commitments while advancing national green economy aspirations.

It is important to note that the MADB is a living document, subject to periodic review and updates as needed. The dynamic nature of the aviation industry and the evolving landscape of environmental considerations require a flexible approach. The blueprint's adaptability is intended to accommodate emerging technologies, regulatory changes, and advancements in sustainable practices. Regular assessments and revisions will ensure that the MADB remains aligned with global best practices and continues to guide the Malaysian aviation sector towards sustainable and environmentally responsible practices.

In Section 9 of this document, two key recommendations are outlined for establishing a national strategy and policy for developing and utilising SAF and formulating a National Carbon Market Strategy. In addition to this, Climate Transition Financing is also crucial to support the airline sector's transition. While integral to the current blueprint, these recommendations also serve as examples of areas that may be subject to adjustment or expansion in future updates to ensure the ongoing relevance and effectiveness of the MADB in achieving Malaysia's decarbonisation goals.

Lastly, the blueprint's vision is also to enable Malaysia to develop a competitive advantage as an ASEAN Sustainable Aviation Hub to attract travellers and airline operators. Airlines seeking to lower their carbon footprint would find Malaysia an attractive choice if airspace management was efficient and its airports were operated sustainably using clean energy and low carbon ground services. Successful management of Malaysia's sustainable aviation development would enable Malaysia to differentiate itself from other regional hubs while establishing leadership in its response to climate change.

2 Introduction to the Malaysian Aviation Landscape and **The Importance of Decarbonising The Sector**

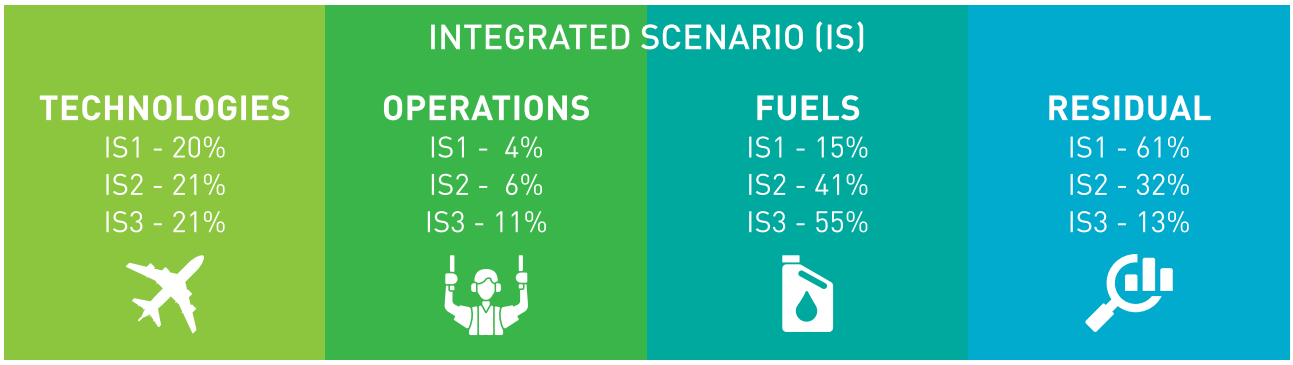
During the 39th International Civil Aviation Organisation (ICAO) General Assembly in 2016, resolutions A39-2 and A39-3 were adopted, focusing on the implementation of Global Market-Based Measures (GMBM) to reduce carbon emissions from international aviation. The objective is to achieve two global aspirational goals for international aviation: annual fuel efficiency improvement of 2% through 2050 and carbon-neutral growth from 2020 onwards respectively. To achieve these global aspirational goals and foster sustainable growth in international aviation, ICAO recommends the implementation of a comprehensive set of measures, encompassing advancements in aircraft technology, operational enhancements, sustainable aviation fuels, and market-based instruments such as the Carbon Offsetting and Reduction Scheme in International Aviation (CORSIA).

In 2016, ICAO formally established CORSIA as a pivotal component of its decarbonisation strategy, setting a target for airline operators conducting international flights to offset emissions exceeding a specified threshold. This approach was designed to prevent a net increase in total emissions from international aviation globally after 2020. Malaysia was among the first group of 88 ICAO Member States to voluntarily participate in the CORSIA as part of its commitment to ICAO's goal to reduce carbon emissions from international aviation.

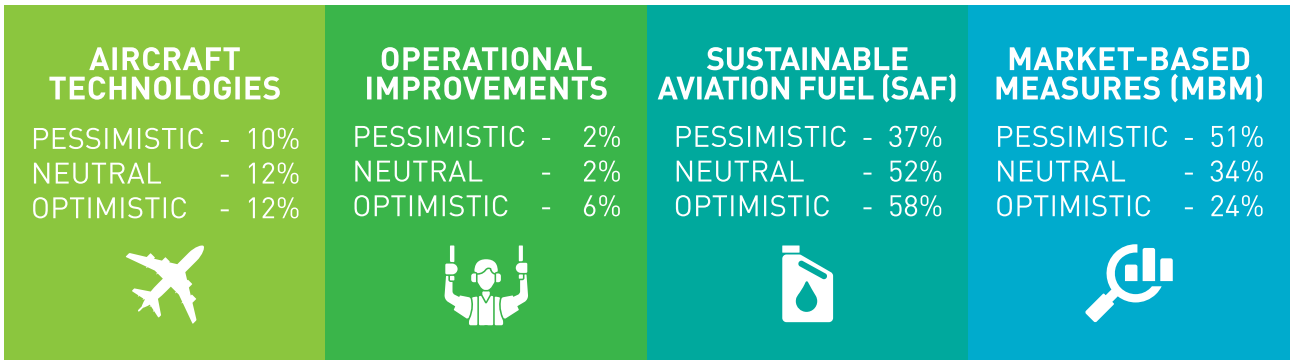
In 2019, the Ministry of Transport Malaysia (MOT) published the National Transport Policy 2019-2030, which outlined a key principle for transitioning toward a green transportation ecosystem. This policy signifies a commitment to introduce initiatives to mitigate pollution, noise, and waste within the transportation sector. The overarching objective is to minimise the environmental impact associated with pollution within the transportation sector.

More recently, at the 41st ICAO Assembly session in 2022, the Long-Term Aspirational Goal (LTAG) of achieving "net zero carbon emissions by 2050" was adopted to decarbonise the international aviation sector. This goal is in line with the Paris Agreement, that was adopted at the 21st session of the Conference of the Parties (COP21) to the United Nations Framework Convention on Climate Change (UNFCCC), to reduce greenhouse gas (GHG) emissions after 2020. The Agreement resolved to limit the global average temperature increase to well below 2 degrees Celsius above pre-industrial levels and to continue efforts to limit the global average temperature increase to 1.5 degrees Celsius above pre-industrial levels. This effort was further supported by the Inter-Governmental Panel on Climate Change (IPCC) Sixth Assessment Report (AR6), which stated that carbon dioxide (CO2) emissions must be net zero by 2050 in order to limit the average temperature increase to within 1.5 degrees Celsius.

ICAO LTAG analysis summarises the reductions from in-sector measures in 2050 as follows:



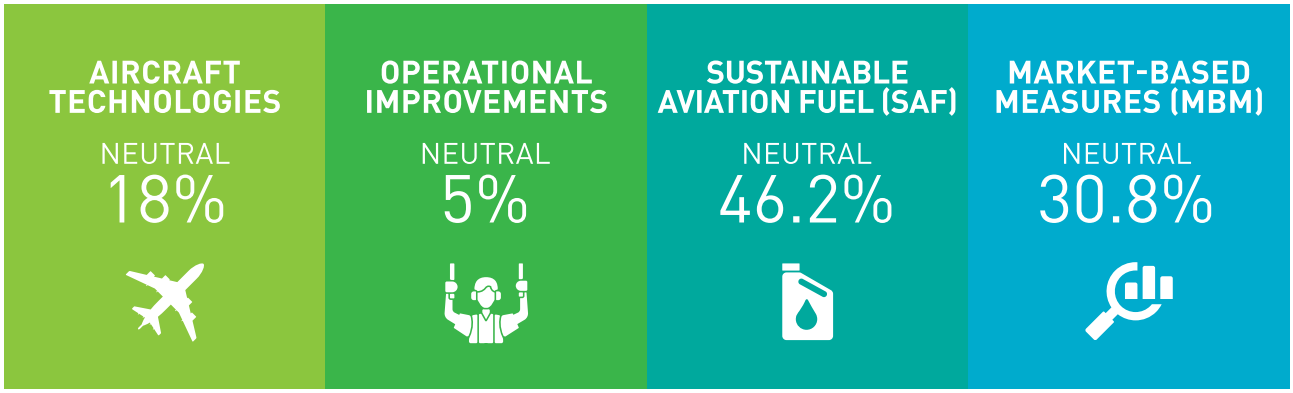
Based on engagement with stakeholders in 2022, comparisons between Malaysia's stand on net-zero emissions by 2050 with the ICAO Long-Term Aspirational Goal for international aviation of net-zero carbon emissions by 2050 scenarios were developed. The Malaysian reduction scenario is as follows:



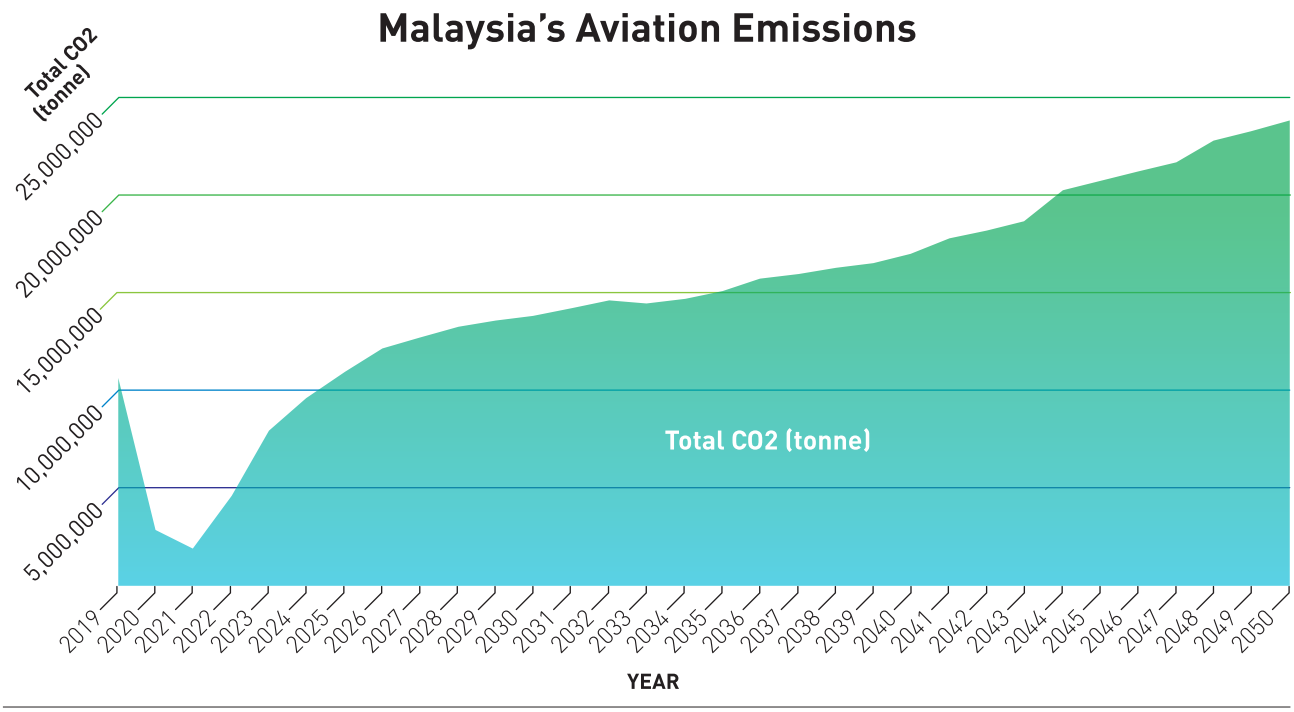
Malaysia decided to adopt the Neutral Scenario as it was considered the most achievable at the point of discussion given that the sector was still deeply affected by the COVID-19 pandemic. Additionally, the shared concern regarding higher SAF prices and low availability did not warrant a higher utilisation percentage in the decarbonisation target.

Since publishing SAP 3, policy developments at domestic and international levels have prompted Malaysia to review its commitments in view of incorporating new targets and ambitions.

In 2023, the neutral reduction scenario was revised given the strong recovery indication, revision of CORSIA baseline, publication of NETR and improved coordination with the Air Navigation Service Provider (ANSP).



All major local airlines and cargo operators that operate internationally and emit significant carbon emissions have begun providing their fuel consumption data from 2010. This data collection and growth estimations are based on publications and references by ICAO. The result is shown in the following graph as the Business As Usual (BAU) baseline data for Malaysia's aviation emissions. Domestic emission makes up between 20 to 30% of total emissions.



Malaysia's national decarbonisation aviation blueprint aims to achieve the following objectives:

1 Chart the country's path to achieve its long-term aspirational goal of reaching net zero for international aviation by 2050;

2 Align Malaysia's aviation net zero pathway from international flights in accordance with ICAO targets;

3 Develop Malaysia's competitive advantage to be a regional sustainable aviation hub;

4 Ensure that Malaysian operators are not unfairly burdened and without recourse to viable solutions to meet decarbonisation targets; and

5 Provide measures for reduction of domestic emissions charted by Nationally Determined Contribution (NDC) and Long-Term Low Emissions Development Strategy (LT-LEDs).

Malaysia has taken a comprehensive strategy to achieve net-zero carbon emissions by 2050, which includes improvements in aircraft technology, operational improvements, SAF, and MBM. Each of these measures contributes to the overarching goal of reducing carbon emissions and fostering sustainable growth in the aviation sector. These measures are further categorised into action groups: airline measures, air traffic management measures, and airport measures, each playing a critical role in implementing the targeted strategies.

The blueprint lists a series of short, medium and long-term measures that can be implemented concurrently or over time, in alignment with measures already identified in Malaysia's State Action Plan. Since emissions from flights is the biggest contributor of the sector's CO2 emissions, the main thrust of the blueprint aims to help airlines decarbonise. These are not limited to airline initiatives alone but include measures by air navigation service providers, airport operators and ground handling companies.

As airlines, air traffic management, airports and ground handlers are the main actors that can deliver emissions reduction, each entity must establish its respective decarbonisation strategies and roadmap. These should be aligned to Malaysia's international commitments under ICAO's Long-Term Aspiration Goal (LTAG) for international aviation to reach net zero by 2050 and the Paris Agreement ambition to limit global temperature rise to 1.5 degrees Celsius.

All actors should develop their respective environmental plans and initiatives, detailing their commitment to emissions reduction programmes, engaging stakeholders, allocating resources, setting reduction targets, mechanisms to measure initiatives, and recording results.

The blueprint also serves to provide the basis for the Ministry of Transport and its related entities to plan for long-term initiatives, especially those which require significant investment in equipment and manpower. The role of regulators is to undertake initiatives that promote safety and sustainability.

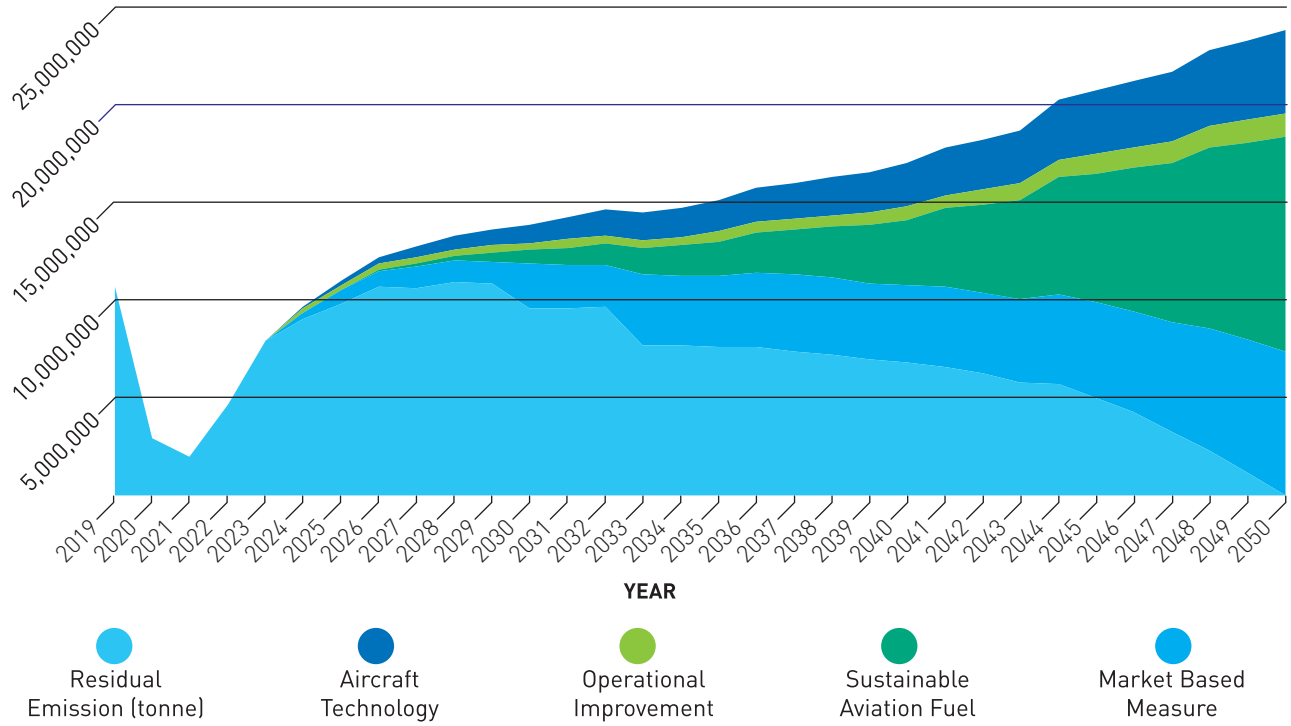
With sustainability concerns expected to shape future developments, the priorities identified are also guided by global best practice standards. Malaysia will leverage international capacity-building assistance to fill policy and skill gaps while investing to build internal resources, whether to upgrade systems or grow its talent pool.

For ease of reference, the blueprint's measures are categorised under four headings: Airlines, Air Traffic Management, Airports and Multi-sector Cooperation. In the latter section, the blueprint recommends national policy-making prerogatives to help secure Malaysia's aviation sector's future and green economy.

3 Malaysia's Net Zero Trajectory

The Malaysia Aviation Decarbonisation Blueprint (MADB) plays a pivotal role in shaping Malaysia's trajectory towards a sustainable aviation future. Based on input from airlines, airport operators and air navigation service providers, MADB establishes a comprehensive framework of industry-wide measures. By laying this foundational groundwork, MADB sets the stage for targeted strategies and initiatives aimed at mitigating emissions, thereby driving Malaysia's aviation sector towards a greener, more sustainable future.

Malaysia Trajectory



Malaysia Reduction Target based on Measure:

The Environment and Sustainability Task Force of the Civil Aviation Authority of Malaysia (CAAM) further developed three scenarios outlining short, medium and long term decarbonisation targets for the sector:

CATEGORY	DECARBONISATION TARGET		
	SHORT (2024-2029)	MEDIUM (2030-2040)	LONG (2041-2050)
Aircraft Technology	1% - 6%	7% - 13%	18%
Operational Improvement	2% - 2.5%	2.5% - 4.0%	5%
SAF	0.2% - 3.7%	5.1% - 19.9%	46.2%
MBM	3.8% - 8.0%	16.8% - 23.1%	30.8%

4 MADB Steering Committee

The Ministry of Transport will establish and chair the MADB Committee to monitor and review the progress of the blueprint. The committee shall meet annually or as required by the committee chairperson. The committee will comprise representatives from the following entities:

MINISTRY OF TRANSPORT	MINISTRY OF FINANCE	MINISTRY OF NATURAL RESOURCES AND ENVIRONMENTAL SUSTAINABILITY
MINISTRY OF ECONOMY	MINISTRY OF INVESTMENT, TRADE AND INDUSTRY	MINISTRY OF PLANTATION AND COMMODITIES
CIVIL AVIATION AUTHORITY OF MALAYSIA (CAAM)	MALAYSIA AVIATION COMMISSION (MAVCOM)	ALL LOCAL AIRLINE OPERATORS
ALL LOCAL AIRPORT OPERATORS	PETRONAS AND OTHER LOCAL SAF PRODUCERS	ANY OTHER STAKEHOLDER AS REQUIRED BY THE STEERING COMMITTEE

5 Malaysia's State Action Plan

Malaysia submits action plans to ICAO once every three years, or as necessary, so that the organisation can compile quantified information to assess global progress in meeting its aspirational goals. The primary objective of the SAP is to assess the country's progress toward achieving net zero emissions by 2050. The action plans include:

- Information on the basket of measures considered by Malaysia;
- Reflections on our capacities and circumstances;
- Quantified information on the expected environmental benefits from implementing the measures; and
- Information on any specific assistance needs.

This is in accordance with operative clauses 10 and 11 of Resolution A39-2: Consolidated statement of continuing ICAO policies and practices related to environmental protection - Climate Change of the ICAO Assembly 2016 where States are urged to develop their respective action plans to

1. report international aviation CO2 emissions;
2. outline their respective policies and actions; and
3. provide information on the basket of measures considered, reflecting their respective national capacities and circumstances, and on any specific assistance needs.

In 2013, Malaysia produced its first State Action Plan (SAP) on CO2 Emissions Reduction. This was followed by a second SAP in 2016. Under State Action Plan No. 3 (SAP 3) submitted in 2022, the focus was on improving operational efficiencies through five mitigation measures. Presently, the Civil Aviation Authority of Malaysia (CAAM) is in the process of updating its fourth SAP (SAP 4) with assistance from the European Union Aviation Safety Agency (EASA). This latest version aims to incorporate mitigation measures from operational improvements, use of Sustainable Aviation Fuels (SAF), and Market-Based Measures (MBM). SAP 4 is expected to be submitted to ICAO by 2024.

The SAP shall contain, at a minimum, the business-as-usual baseline, measures identified to mitigate CO2 emissions, expected results and assistance needs. It is recognised that the forecast of growth and results may be superficial. Therefore, the monitoring of measures implementation shall be conducted at least yearly.

Airlines, airport operators and air navigation service providers are required to monitor and report the implementation of mitigation measures. These data will be analysed and translated into future SAPs.

It should be noted that SAP focuses on international aviation and considers domestic aviation a supplemental benefit. Therefore, detailed information on domestic emissions may not be reflected in the SAP.

6 Airline **Measures**

Airlines are key to decarbonising the aviation sector, as over 90% of carbon emissions is generated during the commission of a flight. Regardless of their models of operation, all airlines have four options to decarbonise: use of aircraft technologies, operational efficiencies, utilisation of SAF and applying market-based measures such as the purchase of carbon credits from the voluntary market.

6.1 OPERATIONAL EFFICIENCIES

Implementing operational efficiency measures is a crucial component of short-term initiatives that airline and airport operators can promptly undertake. Given the dual benefit of cost reduction and emissions reduction, all airlines should prioritise this pathway as an in-sector solution to decarbonise.

Acknowledging the significance of these measures in achieving immediate impact, CAAM identified six specific operational efficiency measures during the engagement session with all airline operators under Malaysia's State Action Plan 4. These measures include:

1. Optimum Flight Level through Continuous Climb / Descent Operations;
2. Reduce Contingency Fuel;
3. Single Engine Taxi;
4. Reverse Idle Thrust;
5. Optimal Flap Landing; and
6. Fuel Load Optimisation.

Airlines will outline their plans in operationalising these measures, guided by CAAM's encouragement and promotion of their application. CAAM will publish guidelines on approval criteria for applying these measures as necessary. The regulator will also support airlines in planning and developing the necessary training standards, operating procedures, and policies. These guidelines may be adapted from existing ICAO guidelines and other global best practices. To enhance awareness and confidence among airlines in implementing these measures, CAAM will organise expert-led workshops and industry-sharing sessions. Through these sessions, new implementers can actively seek guidance and build confidence in applying these measures. This proactive approach is aimed at increasing the likelihood of Malaysia meeting its decarbonisation objectives and fostering the development of a culture centred on target-setting, monitoring, and reporting.

CAAM is also taking progressive steps to implement the 'most capable, best served' principles to encourage operators to adopt operational efficiency procedures. This strategic approach ensures that airlines can realise both financial and environmental benefits from their investments. An example of the practical application of these principles is seen in the actions taken by air navigation service providers. By prioritising the sequencing of aircraft using the most efficient landing procedures, they are able to achieve the highest net national gain in emissions reductions through operational efficiency procedures.

In addition to domestic operators, CAAM is actively introducing measures to encourage all qualifying operators to apply these procedures when operating in Malaysia. The publication of application guidelines for foreign operators emphasises the contribution of these procedures to reducing emissions and noise levels. This initiative not only benefits the environment but also sends a strong signal to the international aviation community about Malaysia's commitment to promoting sustainable aviation practices.

6.2 AIRCRAFT TECHNOLOGIES

Airlines should take actionable steps to enhance flight performance across their route networks, such as operating the latest generation aircraft wherever feasible. For those facing constraints in upgrading their entire fleet, consideration can be given to retrofits that improve flight performance hence reducing fuel burns and subsequently its CO2 emissions. Examples of these retrofits include adding aircraft wing tip extensions, such as Airbus sharklets or Boeing winglets, designed to reduce drag and enhance fuel efficiency. Additionally, airlines are encouraged to invest in upgrading their fleet's flight management systems, enabling operational efficiency measures such as Required Navigation Performance Procedure with Authorisation Required (RNP-AR) and Descent Profile Optimiser.

As an aircraft ages, its performance degrades and this impacts fuel efficiency. Monitoring this progression is crucial for airlines to assess their fleet's status. Thus, airlines are encouraged to consider investing in monitoring systems such as Aircraft Performance Monitoring (APM) and Aircraft Health Monitoring (AHM). These systems offer multiple advantages, including enhancing operational efficiency, ensuring safety, and optimising maintenance. Most significantly, the system will minimise emissions by reducing fuel consumption. Systems like APM, for example, will enable the calculation of performance and degradation factors, which are used in multiple systems, including Flight Management System (FMS) and flight planning systems (e.g. fuel bias and cost index). A precise calculation of the performance factor is crucial for accurate fuel planning and safe reduction of contingency fuel.

Sustainability factors that impact aircraft weight and emission intensity should also be considered when selecting cabin interior fittings. These include the selection of seats, trolleys and carpeting that are made of lightweight and durable materials. Increasing the number of seats in an aircraft in accordance with the manufacturer's specifications also enables airlines to lower CO2 emissions per seat.

In the medium to long term, airlines should actively pursue the transition to aircraft utilising next-generation technology, including 100% SAF compatible aircraft, electric planes, and hydrogen-powered aircraft. Although the latter is not expected to be commercially available before 2035, airlines should support research and development efforts to develop these future solutions.

6.3 SUSTAINABLE AVIATION FUELS

The use of sustainable aviation fuels is regarded as the industry's most promising decarbonisation pathway, pending the commercialisation of zero-emission aircraft. SAF will also play a vital role in the long-term decarbonisation of the aviation industry.

Airlines' main obstacle in utilising SAF is its high cost and lack of availability due to low level of production. However, SAF is expected to become more affordable as production ramps up globally. Airlines are already recognising the role of SAF through voluntary commitments that they make in increasing the SAF volume in their fuel mix. However, further assistance from governments and policy makers are required in bridging the price gap between SAF and conventional aviation fossil jet fuel. The growth in SAF adoption commitments will ensure that fuel companies receive the right signals to increase their SAF production.

The development of the global SAF production industry will necessitate an increase in both availability and cost-effectiveness. Collaboration between industry stakeholders and policy makers should be strategised to ensure a sustained, prolonged supply of SAF and to encourage a wider adoption by airlines. This collaborative effort is integral in shaping a long-term SAF landscape, aligning with one of the NETR's key targets to mandate up to 47% of SAF blending by 2050. More on SAF development in 9.1.

6.4 CARBON OFFSETTING

Offsetting CO_2 emissions through the purchase of carbon offsets via CORSIA is expected to complement and address residual emissions from the sector that would not be attainable though in-sector emissions reduction. Although market-based measures are not in-sector solutions, they are integral in addressing any residual emissions of the sector. Additionally, prospective aviation offsetting has the potential to boost the development and implementation of CORSIA certified carbon projects locally, which will further contribute towards a transition to a sustainable and green economy in Malaysia while unlocking the availability of CORSIA Emission Eligible Units (EEUs) for airlines.

For CORSIA offsetting, airlines are responsible for purchasing CORSIA EEUs from Emissions Unit Programmes and submitting Emissions Unit Cancellation Report for a given compliance period as part of ICAO's monitoring, reporting and verification process.

The Malaysian aviation industry has complied with CORSIA's Monitoring, Reporting, and Verification (MRV) requirements since 2019. An Emissions Report is submitted annually to the relevant aviation authority. Thus far, international aviation emissions have remained well below the baseline year, leading to no offsetting requirements in the Pilot Phase (2021-2023), subject to confirmation upon ICAO publishing the Sector's Growth Factor for 2023.

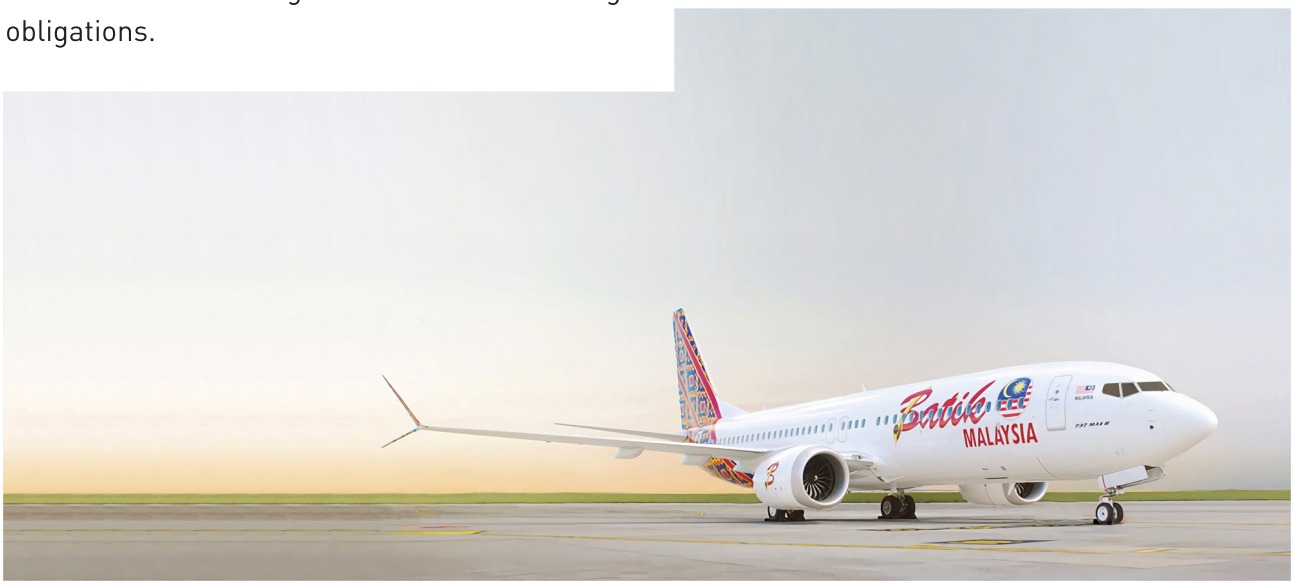
PILOT PHASE			FIRST PHASE			SECOND PHASE								
2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
VOLUNTARY *States volunteer to be part of the scheme from 2021 (more States are encouraged to volunteer).*						**MANDATORY** *With exemptions for: Small Islands, Least Developed Countries, Land-locked Developing Countries and States which have less than 0.5% of air traffic (although they can still volunteer).*								
Operators flying routes between volunteering States will offset emissions based on the average CO_2 growth of the aviation sector.						Operators will offset based on average CO_2 growth of the sector.			Offset obligations shift to include over 20% of individual operator growth.			Offset obligations shift to be over 70% based on individual operator growth.		

OVER 80% OF THE GROWTH IN AIR TRAFFIC CO_2 AFTER 2020 WILL BE OFFSET

The expectation for offsetting for all airlines is expected to begin in Phase 1 (starting in 2024), driven by a positive sector growth. This indicates that emissions offsetting in 2024 will exceed 85% of the 2019 baseline emissions. It is important to note that Phase 1 of CORSIA's offsetting participation by States remains voluntary. Consequently, a route is not covered by the CORSIA offsetting if one or both States connecting the route do not participate in the scheme. However, from 2027 in the second phase, offsetting applies to all Member States with the exception of two categories based on aviation-related and socio-economic criteria. This will result in a significant rise in offsetting obligations.

The final offsetting amount for the Phase 1 compliance cycle (2024-2026) is determined only towards the end of 2027, with the emission unit cancellation report due in early 2028. However, it is likely that airlines must initiate offset purchases well before the deadline.

Beyond CORSIA compliance requirements, airlines should make the best efforts to offset emissions from their domestic flights progressively by purchasing locally-issued credits. This will contribute towards achieving the emission reduction target under Malaysia's Nationally Determined Contribution (NDC).



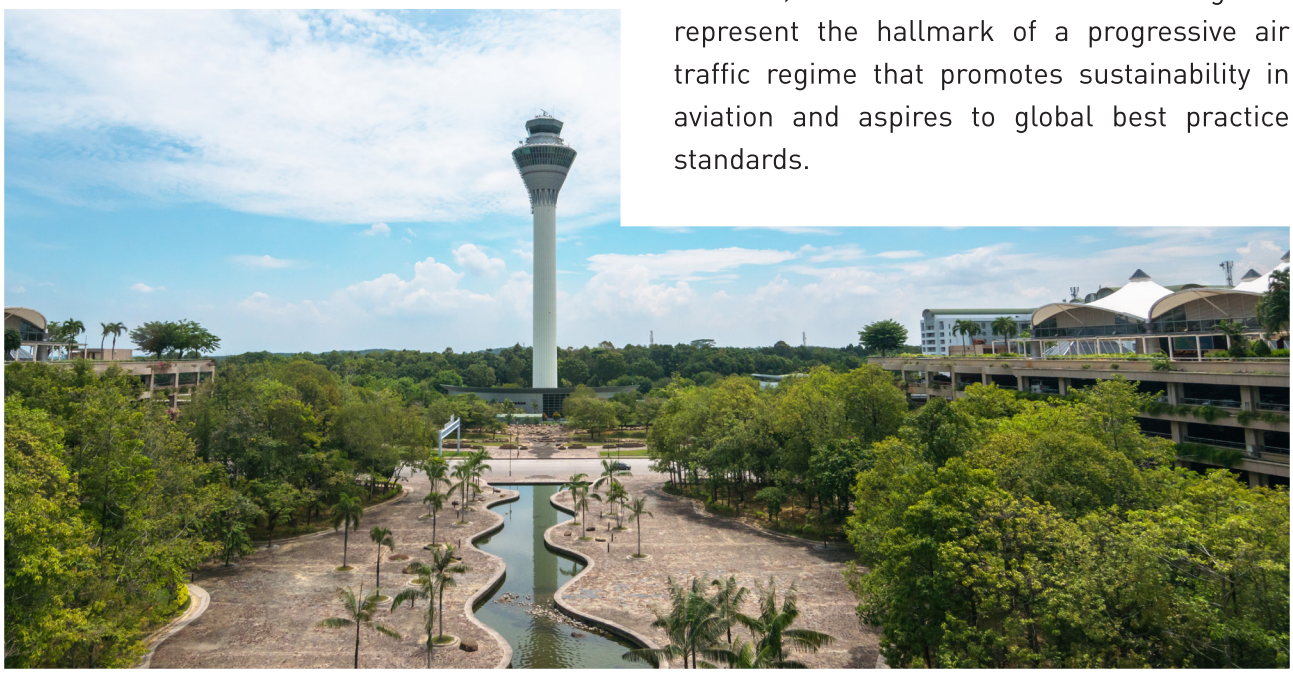
7 Air Traffic **Management Measures**

Besides safety, which is the primary focus for air traffic management, efficiency plays an important role. It enables aircraft to fly the most efficient and optimum flight paths, thereby minimising flight distances, flight time, fuel consumption and CO_2 emissions. Improvements in air traffic management can positively impact all airlines flying into, out of and over Malaysian airspace for all the above reasons, while also resulting in reduction of flight delays, congestion at airports and passenger dissatisfaction. To illustrate, a typical passenger aircraft emits 50 KG of CO_2 emissions per minute. Reducing flight time by 1 minute per flight would reduce CO_2 emission produced when entering Malaysian airspace by 75,600 tonne annually.

To improve the efficiency of the Malaysian air space, CAAM as the Air Navigation Service Provider (ANSP), is to undertake regular reviews of flight routings using airspace analytical solutions. The ANSP can use data gathered by these solutions to review and develop optimal flight paths based on aggregate data of all flights operating the route. Airspace analytical solutions also enable the ANSP to regularly review flight paths, propose air traffic procedure changes that enhance efficiency, track the impact of modifications undertaken and quantify their outcomes.

CAAM formalises regular engagement sessions with airlines to consider operator input. The channel established for this is the CAAM Air Navigation Services Technical Division Stakeholders Engagement Committee (ANSTED CSEC) and its sub-committees. Malaysia will continuously improve air traffic management through short, medium, and long-term measures.

Improvements in air traffic management require public investment in upgrades of equipment and systems, as well as training of personnel. However, their benefits are far-reaching and represent the hallmark of a progressive air traffic regime that promotes sustainability in aviation and aspires to global best practice standards.



BELOW ARE SOME RECOMMENDATIONS:

SHORT-TERM (2024-2029)

7.1 POINT MERGE SYSTEM (PMS) IMPROVEMENTS

The Point Merge System (PMS) is the ATC arrival procedure introduced in KUL to replace the earlier Trombone System implemented in 2014 to accommodate higher air traffic volume.

CAAM will implement three key measures to improve air traffic efficiency:

Increase the number of PMS as entry points to cater to arrival from all directions during peak hours at KLIA	Continue offering midnight Standard Instrument Departure Routes (SIDs) and Standard Terminal Arrival Routes (STARs) for arrival to KLIA during midnight hours	Continue utilising and considering the extension of operating hours of short Standard Terminal Arrival Routes (STARs) at KLIA during non-peak hours as published in the Aeronautical Information Publication (AIP)

7.2 REQUIRED NAVIGATION PERFORMANCE - AUTHORISATION REQUIRED (RNP-AR)

Malaysia is the only country in ASEAN that maintains and operates Required Navigation Performance - Authorisation Required (RNP-AR) approach procedures. As of September 2023, these procedures are operational at 14 airports nationwide. However, given the investments that both sides have made, the utilisation rate of RNP-AR in Malaysia remains relatively low at around 20% of all flight landings in 2022 compared to utilisation rates above 80% at North American airports.

To realise the full potential of Malaysia's RNP-AR investments, CAAM will introduce procedures and regulations to increase the utilisation rate of RNP-AR progressively. These activities have the potential to create a virtuous circle, as consistency of implementation and proven results will encourage more operators to invest and obtain regulatory approval to qualify and contribute to higher utilisation rates.

PROCEDURES:

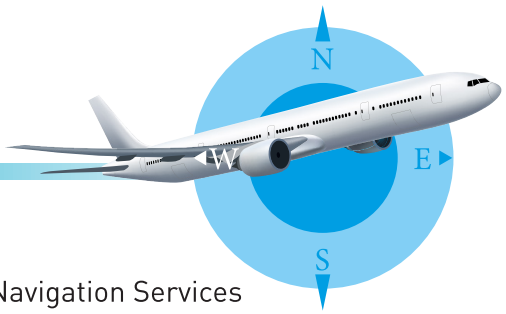
- RNP-AR is to be made the primary approach procedure above other approach procedures available at the airport by 2026 or when all airlines are ready for full implementation, whichever is earlier. ATC should endeavour to clear approved traffic to utilise RNP-AR when conditions permit, in the aim of raising adoption rates.

REGULATIONS:

- All local operators of jet aircraft above a predetermined maximum take-off weight (MTOW) shall include RNP-AR in their OPS SPEC;
- All foreign operators of jet aircraft above a predetermined MTOW with RNP-AR capabilities shall be encouraged to utilise the procedure. An application form shall be published and made accessible;
- All new aircraft above a predetermined MTOW shall be equipped with RNP capabilities;
- All flight crew operating aircraft above a predetermined MTOW shall undergo RNP-AR initial and recurrent training;
- All runways with more than a minimum level of annual jet movements shall have an RNP-AR approach designed;
- RNP-AR utilisation workshops and seminars shall be conducted at every airport regularly to encourage adoption; and
- All operators shall provide CAAM with a report of RNP-AR utilisation rates and emissions savings biannually for review and monitoring.

Given Malaysia's position as the key ASEAN country with RNP-AR approach procedure availability, a high utilisation rate will spotlight the country as a leading enabler of sustainable aviation.

MEDIUM TERM (2030-2040)



7.3 PERFORMANCE-BASED NAVIGATION (PBN)

Historically, flight paths were designed to accommodate aircraft with the lowest performance specifications. However, modern aircraft have the capability to fly direct routes with a high degree of accuracy. Flight paths that were built around ground-based navigation aids are no longer required by the majority of aircraft flying in Malaysia today.

CAAM's Air Navigation Services Technical Division has announced its roadmap to transition to performance-based navigation (PBN) at all Malaysian airports by the end of 2025. This transformation will align Malaysia with ICAO's Global Air Navigation Plan to promote PBN to enhance safety while increasing airspace efficiency, accessibility, and capability, and at the same time also reduce costs.

CAAM shall complement this exercise with a full review of installed air traffic management navigation equipment to streamline and remove ground-based aids that are obsolete, in need of replacement or require high maintenance costs. With the transition to PBN, ground-based aids may no longer be necessary at airports that operate only jet aircraft.

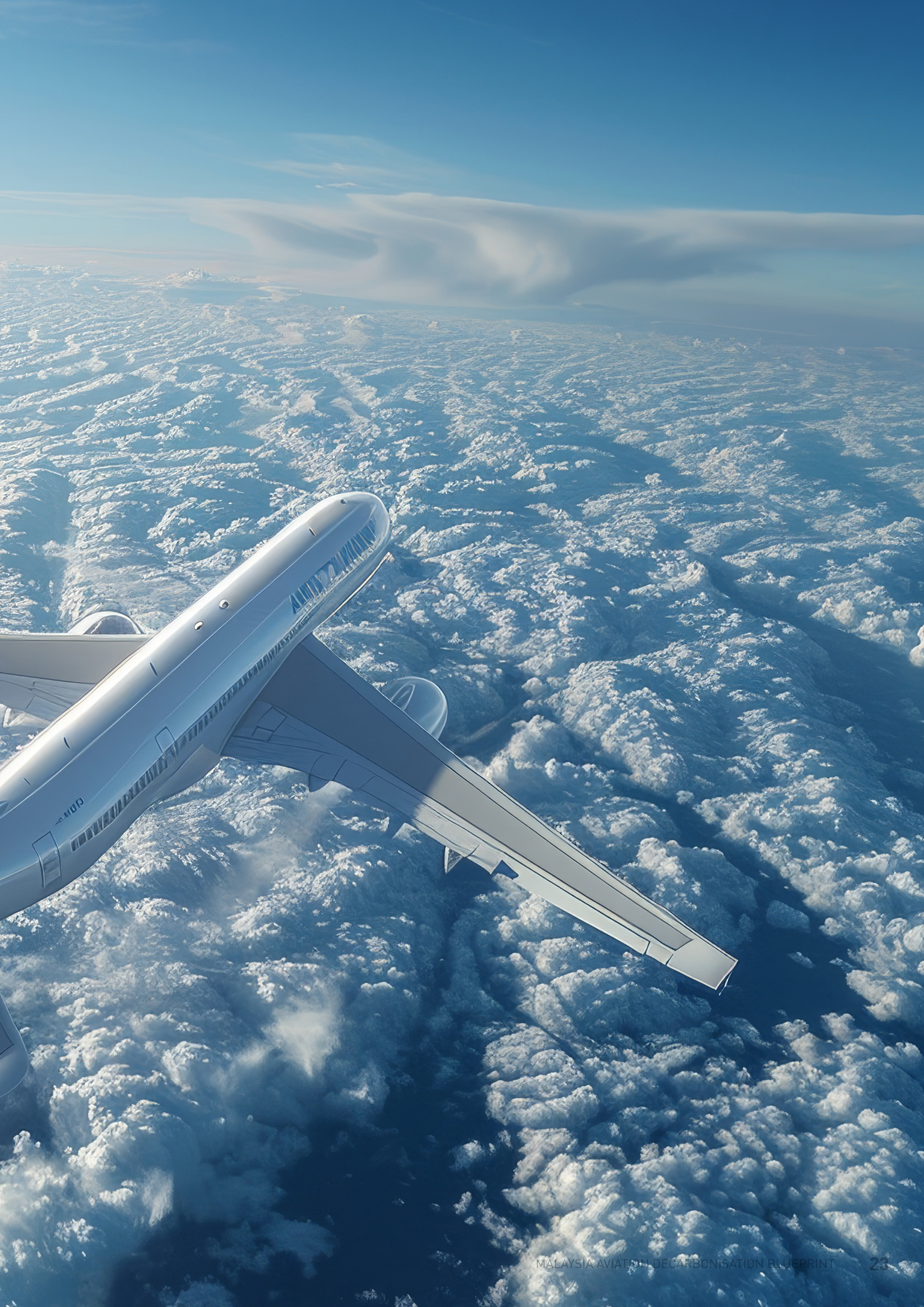
LONG TERM (2041-2050)

7.4 AIRSPACE REDESIGN

CAAM has commissioned a study of the Kuala Lumpur Metroplex to take advantage of a PBN-based airspace for the capital city by modelling the airspace design and analysing opportunities for efficiency gains in terms of reduced flight delays, flight times, fuel consumption and greenhouse gas emission.

CAAM plans to use the study's findings to allocate future resources for an airspace redesign exercise based on updated traffic growth projections. All airlines will be engaged in the study and future engagements to improve Malaysian airspace. This will help ensure an optimal outcome of the exercise, balancing the needs of operators, ANSPs and regulators.

CAAM is constantly exploring opportunities to upgrade current flight paths for more efficient routes and to meet air traffic demand.



8 Airport **Measures**

The design, operations and ease of use of airports significantly impact aircraft ground emissions. Larger airports and inefficient allocation of parking bays require longer on-ground taxiing. Airports limited in taxiways also cause delays and longer queues. Another aspect of airports that impacts airlines is their use of and ability to supply green energy alternatives such as SAF, biodiesel and clean electricity. These are essential for airlines to fly greener and convert to e-ground equipment such as baggage trolleys, push-back vehicles and ground power units.

For Malaysia to gain currency as a sustainable aviation hub, all these factors must be addressed to enable the climate transition of Malaysian carriers and for foreign airlines to choose Malaysia as a destination.

8.1 AIRPORT COLLABORATIVE DECISION MAKING (A-CDM)

Technology offers the opportunity to reduce taxi times and therefore reduce CO2 emissions significantly. Introduction of information-sharing solutions such as Airport Collaborative Decision Making (A-CDM) can bring such benefits. Taxi times have an environmental impact as aircraft are burning fuel to get to the runway for departure.

Where a long taxi is anticipated due to airport congestion, Air Traffic Control should provide early notice to pilots of the traffic situation (e.g. the number of arrivals and departures before the aircraft can take off) as this would influence pilots' decision to perform the Single Engine Taxi procedure. This information would assist pilots in deciding on when to start the second engine to meet the aircraft manufacturer's minimum warm-up time before departure.

Aircraft parked at the stand emits 6-10 times less CO2 emissions than when taxiing. With A-CDM, aircraft can wait at the parking stand and only push back and start the taxi when the runway traffic situation is optimum.

Malaysia first mooted the implementation of A-CDM as early as 2018. However, it has been delayed due to COVID-19 disruptions and data gap issues. With the latter now addressed, the project has been put on track to enable A-CDM trials at KUL by early 2024.

This will enable KUL to be on par with developments at other regional hubs. For information, A-CDM was activated in Singapore in 2016, Bangkok in 2020 and Jakarta in 2023, while two rounds of tests were conducted in Hanoi in 2024. Other major Asian airports where this has been implemented are in Hong Kong, Korea, China and India.

With future flight increases, A-CDM will also be implemented at any other domestic airports which meet the basic requirements.

8.2 SUBSTITUTING APU WITH GROUND POWER & PRECONDITIONED AIR CART

All airlines operating at Malaysian airports should be provided with facilities and options to utilise Ground Power Units (GPUs) and Preconditioned Air (PCA) Units during transits and during aircraft servicing activities such as aircraft cleaning and maintenance tasks.

Either airport operators or ground handling companies can supply the GPUs and PCA units. The usage of GPUs and PCA units eliminates the need for airlines to use their aircraft's Auxiliary Power Unit (APU) while aircraft are stationary on the ground. A best practice case of this is at many airports in China, where it is mandatory for airlines to use GPUs, if available, during transits.

APU usage typically emits 10-20 times more CO2 emissions than GPUs. However, despite the emissions savings potential, airlines continue to use the aircraft's APUs. Airlines, airports and ground handling companies should come to an agreement on fees that would be economically beneficial for airlines to reduce usage of APUs.

8.3 ENERGY EFFICIENCY

The environmental impact of operational airports stem mainly from energy and water consumption. Total carbon emissions associated with airports include Scope 1 emissions of the airport activities, Scope 2 emissions of electricity use and Scope 3 emissions of airside activities at the airports mainly by airlines, ground handlers and other airport stakeholders. Similar to airlines' approach to fuel utilisation, airports should aim to increase energy efficiency alongside plans to increase renewable energy usage.

Airport operators should invest in technologies that help reduce energy intensity for cooling and lighting. This applies to airport terminals as well as airside areas such as apron, taxiways and aerobridges. Solar energy is an option for airport operators to reduce energy intensity and the most favourable due to geographical conditions. For example, as of 2024, Malaysia Airports has installed 22.5 MWp Solar power capacity at six (6) airports managed by them. In reducing the Scope 2 emission, airport operators should establish the Renewable Energy Roadmap to ensure a reduction of Scope 2 emission will be materialised.

Airport operators should invest in building automation systems (BAS) that contribute to large recurring savings by monitoring temperature, lighting and pressure. BAS can operate systems only when needed and use the least possible energy when they are running. Examples of its use to control baggage handling systems can be found in Toronto and Columbus airports, where belt systems are separated into energy management zones that can be shut down if the gates they serve are not in use.

8.4 GROUND ELECTRIFICATION AND GREEN ENERGY SUPPLY

Aside from airlines, ground handlers and airports should also set targets to reduce CO2 emissions from ground activities. This would require a gradual transition to the use of electric ground vehicles to replace the current diesel-powered ones.

As airlines and ground handling services begin to undertake airside electrification by substituting ground vehicles with electric alternatives, airports must install charging points and ensure that sufficient clean energy supply is available to power this change.

Current ground equipment suitable for conversion to e-vehicles are baggage trolleys, tugs, and push-back trucks. Airports should formalise a process to seek annual projections by airlines and ground handlers on their e-vehicle rollout plans and incorporate these into its upgrading and expansion plans.

Airports must proactively prepare for the integration of Sustainable Aviation Fuel (SAF) into the fuel supply chain by 2024. This involves upgrading fuelling and storage infrastructure onsite as needed. Airports should also plan ahead to supply a substantial amount of renewable energy to facilitate the operation of hydrogen- and electric-powered aircraft. Recognising that by 2050, all aircraft may adopt these technologies, airports need to take early action to accommodate these changes. Specifically, significant investments into airport infrastructure are imperative to support next-generation fuel technologies such as green hydrogen.

8.5 AVIATION WASTE MANAGEMENT

Circularity should be promoted in the handling of aviation waste. The aviation industry operates in a closed-loop environment, which makes it ideal for improving waste capture from the industry.

All airports should develop inflight waste management protocols and appoint waste-certified operators to dispose of inflight waste in accordance with current laws and regulations. Where airlines manage their own waste from facilities located in Malaysian airports, airlines should be provided with published rules and regulations on the disposal of different waste categories and protocols for disposal of domestic and international inflight waste. This ensures that foreign pathogens are not inadvertently introduced into the local ecosystem, which may result in ecological contamination.

8.6 AIRPORT ENVIRONMENTAL MANAGEMENT PLAN (EMP 2.0)

The Environmental Management Plan (EMP 2.0) for Malaysia Airports focuses on supporting the pathway of Net Zero 2050. Although airport operations are highly dependent on decarbonisation efforts, other environmental elements that have been identified focus on reducing the impacts on the airport community.

Eight key elements namely energy, water, waste, carbon, land contamination, noise pollution, air quality and wildlife are managed, reviewed annually and updated periodically to reflect new/ emerging requirements, as well as to keep pace with advances in airport sustainability initiatives and future aspirations.

The Airport Carbon Management through Airport Carbon Accreditation (ACA) is the leading programme in creating greener airport operators. To promote decarbonisation, improvement measures shall be taken into consideration, such as the transition to EV fleet, adequate EV charging stations (airside/ landside), increase onsite solar energy sourcing (solar farm), develop Renewable Energy Roadmap and increase level of ACA certification to level 4/ level 4+. The integration of EMP 2.0 into the ESG Framework is a commitment of the airports to comply with policies, charters, future casts, strategic targets and implementation plans.

9 Multi-Sector **Co-operation**

To address challenges in decarbonising the aviation sector and realise Malaysia's green economy opportunities, a macroeconomic approach has to be taken to develop and implement necessary measures such as law, policy, and initiative, including the necessary support such as finance, technology and capacity building. The whole national approach needs to be implemented to leverage the knowledge and expertise of the stakeholders including the Government, state governments, private sector and non-government organisations. This inclusive approach is important to meet Malaysia's international climate-related obligations and commitments without compromising the aviation sector's competitiveness.

The Government must also consider other factors in developing Malaysia's strategies to achieve LTAG based on the country's national timeframe. These include Malaysia's unique circumstances and respective capabilities related to the level of development, maturity of aviation markets, sustainable growth of its international aviation and national priorities of air transport development.

9.1 NATIONAL STRATEGY FOR SUSTAINABLE AVIATION FUEL (SAF)

The imperative need for a National Strategy for Sustainable Aviation Fuel (SAF) stems from its crucial role in advancing the decarbonisation agenda within the aviation sector. SAF is a pivotal element in this effort, significantly reducing CO2 emissions. Establishing a comprehensive National Strategy for SAF becomes essential to align with Malaysia's commitment to mandate SAF utilisation, as outlined in the National Energy Transition Roadmap (NETR). This strategy should also be rationalised with the targets identified for Malaysia's aerospace sector in the New Industry Master Plan (NIMP) 2030 .

The key objective is to ensure a stable supply of domestically produced SAF that is not only environmentally sustainable but also globally competitive. Collaboration among various ministries is integral to promoting the development and deployment of domestic SAF. However, formidable challenges, particularly related to the affordability and availability of SAF, must be addressed to realise the full potential of this sustainable fuel source.

Given that these challenges are overarching national issues, the implementation of an appropriate strategy is crucial. The strategy for SAF production and utilisation will be meticulously crafted to accommodate the country's economic circumstances. It must be done with a nuanced understanding of the challenges faced by Malaysian operators, ensuring that efforts to decarbonise the sector do not inadvertently compromise the competitiveness of Malaysian carriers or jeopardise Malaysia's status as a regional aviation hub.

In essence, the establishment of a National Strategy for SAF is not just a regulatory imperative but a strategic move to propel Malaysia towards sustainable aviation practices. It represents a commitment to balancing environmental goals with economic considerations, fostering a thriving domestic SAF industry, and reinforcing Malaysia's position in the regional aviation landscape.

Several issues require further examination through detailed studies. These include the feasibility studies of the feedstock, pathways, technologies for SAF, and regulations pertaining to feedstock trade. Additionally, a reassessment of the life cycle emissions factor for SAF produced from sustainable palm oil and any local feedstocks from Malaysia is necessary. Furthermore, incentives related to clean energy tax credits should be carefully examined for effectiveness.

However, recognising the importance of SAF to medium-to-long term decarbonisation and its role in the country's plans to increase energy security and economic development, the Government may consider a mix of positive incentives and targeted policy-making to achieve its objectives.

Malaysia should explore collaborations with potential partners to diversify regional SAF production pathways as well as promote and develop regional SAF feedstocks. This will help encourage the development and adoption of SAF across borders, including through strong capacity-building activities that can facilitate its deployment.

9.2 FORMULATION OF A NATIONAL CARBON MARKET STRATEGY

CORSIA offsetting obligations for airlines based in participating States is expected to begin in its first phase (2024-2026) onwards. Under CORSIA regulations, airlines can offset international emissions by purchasing carbon credits only from approved CORSIA Emission Unit Programmes (EUPs). However, there is a lack of CORSIA EEUs availability in the carbon market today due to issues surrounding corresponding adjustment for Internationally Transferred Mitigation Outcomes (ITMOs) under Article 6.2 and 6.4 of the Paris Agreement.

Even under an optimistic LTAG scenario, the global aviation industry will still depend on market-based measures to address 13% of residual CO2 emissions to meet its net zero targets by 2050. The shortage of CORSIA EEUs will limit Malaysian carriers' ability to reach net zero, thereby escalating the cost of aviation decarbonisation.

However, the Government could address this gap by developing the necessary policies to facilitate the implementation of carbon projects in Malaysia. These policies should align with the UNFCCC decisions on compliance with the carbon market under the Paris Agreement and fulfil CORSIA standards. In this regard, formulating a National Carbon Market Strategy is crucial for Malaysia to support the economy-wide decarbonisation efforts through carbon market mechanisms and contribute towards achieving climate targets under the UNFCCC and the Paris Agreement. Simultaneously, capacity-building efforts should be undertaken to elevate promising projects for eventual CORSIA EEU.

The development of a regional carbon market standard or programme that meets UNFCCC's and ICAO's requirements could also be explored. Among the potential carbon market standards or programmes that could be developed within the region are nature-based, with the aim of promoting the restoration and conservation of natural ecosystems.

9.3 CLIMATE TRANSITION FINANCING

Effective financing mechanisms are necessary to support the transition toward sustainable practices and meet ambitious decarbonisation targets in the aviation sector. Airlines, absorbing a portion of the associated costs, may need to augment their revenues, and airfares could rise. The ability to access various financing options, including government support, plays a crucial role. In this regard, the Ministry of Finance (MOF), in collaboration with the World Bank, is presently conducting a feasibility study on the implementation of carbon pricing instruments in Malaysia.

The study aligns with the Carbon Market Policy and the Climate Change Bill which are being developed by the Ministry of Natural Resources and Environmental Sustainability. Furthermore, the Government consistently explores additional financing mechanisms from multiple sources to support the transition towards green financing in Malaysia.

Airlines are given complete pricing flexibility to fund their decarbonisation and environmental activities by introducing carbon fees. This decision is considered commercial and is best left to individual airlines to determine based on their business models, market dynamics, and sustainability goals. However, regulatory bodies and stakeholders need to monitor the implementation of carbon fees to ensure transparency and fairness across the industry. Additionally, airlines, regulatory bodies, and other stakeholders can collaborate to facilitate knowledge sharing and best practices to maximise the effectiveness of carbon pricing initiatives in the aim of driving sustainable development within the aviation sector.

10 Conclusion

In response to the dynamic shifts in the global aviation landscape, the Malaysia Aviation Decarbonisation Blueprint stands as a strategic roadmap, aligning the nation with progressive international endeavours and fortifying its commitment to environment sustainability. This is in line with global developments in civil aviation underscored by recent legislative milestones such as the Sustainable Skies Act in the United States and the ReFuelEU package in the European Parliament, which underlines the urgency for the aviation sector to address its environmental impact.

Closer to home, ASEAN governments, including Malaysia, are taking substantive steps to integrate Sustainable Aviation Fuel (SAF) requirements and carbon pricing regimes. The publication of Malaysia's National Energy Transition Roadmap and Singapore Sustainable Aviation Hub Blueprint exemplify the region's collective commitment to a sustainable aviation future.

The overarching objectives outlined in Malaysia's Aviation Decarbonisation Blueprint of achieving net zero by 2050 set a robust framework for the country's aviation sector. These are aligning with international targets, fostering regional hub competitiveness, ensuring fair burden-sharing and active participation in the global sustainability forum.

The blueprint's comprehensive approach encompasses short, medium, and long-term measures. Recognising the complex and interwinding nature of decarbonising the sector, the blueprint addresses a spectrum of stakeholders, extending its reach to air navigation service providers, airport operators, and ground handling companies.

The blueprint calls for individual entities to establish bespoke decarbonisation strategies aligned with international commitments such as ICAO's Long-Term Aspiration Goal (LTAG), the Conference on Aviation Alternative Fuel (CAAF)/3 and the Paris Agreement. The emphasis on developing environmental plans, engaging stakeholders, and appointing 'Sustainability Champions' underscores a holistic approach to emissions reduction.

Beyond operational considerations, the blueprint plays a pivotal role in guiding long term initiatives, acknowledging the crucial role of regulators in promoting both safety and sustainability. The prioritisation of sustainability aligns international standards and global best practices, leveraging international capacity-building assistance to address policy and skill gaps while nurturing internal resources.

Categorised under key domains — Airlines, Air Traffic Management, Airports, and Multi-sector Cooperation — the blueprint provides a practical guide for immediate action and recommends national policy imperatives essential for securing Malaysia's aviation sector and advancing its green economy.

In conclusion, the Malaysia Aviation Decarbonisation Blueprint is not merely a strategic document; it is a testament to the nation's commitment to shaping a sustainable aviation future, contributing to global efforts, and ensuring a resilient and competitive position in the evolving landscape of green aviation.

Glossary

ACA	Airport Carbon Accreditation
A-CDM	Airport Collaborative Decision-Making
AHM	Aircraft Health Monitoring
ANSP	Air Navigation Service Provider
ANSTED CSEC	Air Navigation Services Technical Division Stakeholders Engagement Committee
APM	Aircraft Performance Monitoring
APU	Auxiliary Power Unit
AR6	Sixth Assessment Report
ASEAN	Association of Southeast Asian Nations
ATC	Air Traffic Controller
ATM	Air Traffic Management
BAS	Building Automation Systems
BAU	Business As Usual
CAAF	Conference on Aviation Alternative Fuel
CAAM	Civil Aviation Authority of Malaysia
CO2	Carbon Dioxide
CORSIA	Carbon Offsetting and Reduction Scheme in International Aviation
EASA	European Union Aviation Safety Agency
EEUs	Emission Eligible Units
EMP 2.0	Environmental Management Plan 2.0
EUPs	Emission Unit Programmes
EV	Electric Vehicle
FMS	Flight Management System
GHG	Greenhouse Gas
GPUs	Ground Power Units
ICAO	International Civil Aviation Organisation
ITMO	Internationally Transferred Mitigation Outcomes
IPCC	Intergovernmental Panel on Climate Change
KLIA	Kuala Lumpur International Airport
LCAF	Lower Carbon Aviation Fuel
LTAG	Long-Term Aspirational Goals
LT-LEDs	Long-Term Low Emissions Development Strategy
MADB	Malaysia Aviation Decarbonisation Blueprint
MBM	Market-Based Measures
MOF	Ministry Of Finance
MOT	Ministry of Transport
MRV	Monitoring, Reporting, and Verification
NETR	National Energy Transition Roadmap
NIMP	New Industry Master Plan
PBN	Performance-Based Navigation
PCA	Preconditioned Air
PETRONAS	Petroliam Nasional Berhad
PMS	Point Merge System
RNP-AR	Required Navigation Performance - Authorisation Required
SAF	Sustainable Aviation Fuel
SAP	State Action Plan
SID	Standard Instrument Departure
STAR	Standard Arrival Route
UNFCCC	United Nations Framework Convention on Climate Change

MINISTRY OF TRANSPORT
MALAYSIA

No. 26, Jalan Tun Hussein, Presint 4, 62100 W.P. Putrajaya, Malaysia

T. 03 8000 8000 | F. 03 8888 0158 | HL. 1800 88 7723