

SINGAPORE SUSTAINABLE AIR HUB BLUEPRINT EXECUTIVE SUMMARY

Climate change is an existential challenge that can cause widespread disruptions and impact air travel directly, affecting critical airport infrastructure and aircraft performance and causing operational delays and disruptions. Combating climate change is a matter of great urgency and priority. Recognising this, the International Civil Aviation Organization (ICAO) and its Member States have adopted a long-term global aspirational goal (LTAG) of net zero carbon emissions for international aviation by 2050. This sends a strong signal on the international community's commitment towards sustainable aviation. The realisation of LTAG requires global joint effort shared across all countries, sectors, and vocations, as well as greater climate consciousness amongst businesses and the travelling public.

As an international business, aviation and aerospace centre, the sustainable development of the Singapore air hub is a priority for Singapore as we press ahead to grow the air hub. The Civil Aviation Authority of Singapore (CAAS) has developed the Singapore Sustainable Air Hub Blueprint as Singapore's State Action Plan for the decarbonisation of its aviation sector and sustainable aviation growth. Through the Blueprint, Singapore also hopes to be a pathfinder and convenor for cross-sectoral and public-private partnership, to work with other countries and international organisations to support sustainable aviation growth.

The Blueprint adopts a balanced approach to the long term, sustainable growth of Singapore's aviation sector. Environmental sustainability needs to be balanced with the Singapore air hub's competitiveness to support the growth of the aviation industry in the upcoming decades. The Blueprint demonstrates this resolve and sets out Singapore's medium-term and long-term targets, as well as concrete steps that CAAS and the aviation stakeholders will take to decarbonise Singapore aviation.

Under the Blueprint, CAAS will work with aviation stakeholders to reduce domestic aviation emissions from airport operations¹ by 20% from 2019 levels (404ktCO₂) in 2030 and achieve net zero domestic and international aviation emissions² by 2050. To achieve these goals, CAAS will roll out 12 initiatives across the airport, airline, and air traffic management (ATM) domains to decarbonise the Singapore aviation sector. CAAS will also put in place five enablers to create the conditions for the effective implementation of these decarbonisation initiatives.

¹ This covers emissions from operations of vehicles, facilities, and buildings for aircraft, passenger, baggage, and cargo handling at Changi Airport Terminals 1 – 4 and Seletar Airport. It does not include targets for Changi East developments, including Terminal 5, which are not yet operational today. These will be determined separately.

² This covers emissions from international flights operated by Singapore-based operators.

Singapore Sustainable Air Hub Blueprint

Reduce domestic aviation emissions from airport operations by 20% from 2019 levels in 2030 and achieve net zero domestic and international aviation emissions by 2050

<p align="center"><u>Airport domain – Maximal efforts to reduce energy use and deploy renewables</u></p> <ul style="list-style-type: none"> ➤ Solar power deployment ➤ Clean energy airside vehicles ➤ Building energy efficiency ➤ Low-carbon electricity imports ➤ Resource circularity through waste-to-energy 	<p align="center"><u>Airline domain – Build ecosystem to support the use of Sustainable Aviation Fuel (SAF) in Singapore</u></p> <ul style="list-style-type: none"> ➤ National SAF target and SAF levy ➤ Central SAF procurement ➤ SAF production in Singapore and the region ➤ Airline fleet renewal and operational improvements 	<p align="center"><u>Air Traffic Management domain – Operational improvements to increase efficiency and reduce fuel burn</u></p> <ul style="list-style-type: none"> ➤ Advanced demand-capacity balancing implementation ➤ Performance-based navigation enhancement ➤ Gate-to-gate trajectory optimisation
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Critical Enablers – Build coalitions for action

Policy and regulation
 Industry development
 Infrastructure planning and provision
 Workforce transformation
 International partnerships and collaborations

Airport domain: Maximal efforts to reduce energy use and deploy renewables

Airports are complex ecosystems serving as gateways for air travel and connectivity. Due to their large-scale infrastructure, operational systems, and ground operations, they are highly energy intensive. CAAS will advance five initiatives to reduce emissions and scale up green energy use at Changi Airport. These include:

a) Solar power deployment

CAAS and Changi Airport Group (CAG) are working to increase solar power deployment at Changi and Seletar Airports, by installing more solar photovoltaic (PV) systems on available rooftop spaces of airport buildings and studying the feasibility of airfield solar deployment. As of end-2023, Changi Airport has more than 20MWp of installed solar capacity, generating close to 4% of its 2019 electricity consumption of about 700GWh. Ongoing plans to install more solar PV systems on available rooftop will generate a further 6%. Solar panels will also be deployed at Seletar Airport.

b) Clean energy airside vehicles

The Changi Airport community is committed to expand the use of cleaner energy for airside vehicles, to have the entire airside vehicle fleet operate on cleaner energy sources by 2040, and for all new light vehicles, such as cars, vans and minibuses, and selected new heavy vehicles like forklifts and tractors to be electric from 2025, along with the installation of additional charging stations. To support this transition, CAAS will work with stakeholders to commence a trial on the use of renewable diesel (RD) for airside vehicles, particularly heavy and specialised vehicles, in 2024. The trial will allow CAAS and the airport community to better understand the feasibility, costs, and operational impact of using RD as a cleaner energy source for airside vehicles.

c) Building energy efficiency

CAAS, CAG, and other airport partners are working to continually improve the energy efficiency of Changi Airport's terminal buildings, especially for air-conditioning systems, which account for more than half of the buildings' total electricity consumption. Besides progressively upgrading the chiller systems in the terminal buildings, Changi Airport has been pursuing passive design strategy such as the use of heat reflecting facade materials to lower energy use from air-conditioning systems. The new Terminal 5 will also be designed to achieve the stringent Green Mark Platinum Super Low Energy Building standard.

d) Low-carbon electricity imports

As most of the carbon emissions from airport operations is due to electricity consumption at the airport, the airport will leverage the Energy Market Authority's (EMA) plans to reduce our national grid emission factor (GEF), including the use of low-carbon electricity imports, for the aviation sector to reach net zero domestic emissions by 2050.

e) Resource circularity through waste-to-energy

CAAS will work with stakeholders to study the potential and feasibility of an on-site waste-to-energy facility at Changi Airport, which could possibly use waste as a feedstock to generate electricity or biofuel for use within the airport. The study will entail waste audit and technical assessment to establish the viability and most effective waste-to-energy pathway.

Airline domain: Build ecosystem to support the use of SAF in Singapore

Flight operations account for the bulk of international aviation emissions and emissions from aircraft operations are inherently hard to abate. The use of SAF is a critical pathway for the decarbonisation of aviation and is expected to contribute around 65% of the carbon emissions reduction needed to achieve net zero by 2050. CAAS will undertake four initiatives to build an ecosystem to support and sustain the use of SAF in Singapore and to progressively decarbonise airline operations. These include:

a) National SAF target and SAF levy

To kickstart SAF adoption in Singapore, flights departing Singapore will be required to use SAF from 2026. We will aim for a 1% SAF target for a start, to encourage investment in SAF production and develop an ecosystem for more resilient and affordable supply. Our goal is to raise the SAF target beyond 1% in 2026 to 3 – 5% by 2030, subject to global developments and the wider availability and adoption of SAF. CAAS will introduce a SAF levy for the purchase of SAF to achieve the uplift target. As the market for the supply of SAF is still nascent and the price of SAF can be volatile, this approach will provide cost certainty to airlines and travellers.

b) Central SAF procurement

To further manage the cost of using SAF, the procurement of SAF will be centralised, using the levies collected to aggregate demand and reap economies of scale. Businesses and organisations will also be invited to use the central procurement mechanism for their respective voluntary SAF purchases to reduce their carbon emissions from air travel in a credible and cost-effective manner.

c) SAF production in Singapore and the region

CAAS and the Singapore Government will work closely with industry partners to increase SAF production capacity in Singapore and the region. We can tap into the wide availability of potential feedstocks in the region and the presence of an existing petrochemical sector in Singapore. This will support the increasing demand for SAF in Singapore and the wider region.

d) Airline fleet renewal and operational improvements

Singapore carriers have continuously embarked on fleet modernisation, investing in newer and fuel-efficient aircraft, which also reduce emissions. Our carriers have also made operational improvements to reduce fuel burn, such as weight reduction initiatives and reduction of aircraft auxiliary power unit use on ground. In addition, flight plans and flight management are optimised for in-flight fuel savings; this includes improving airspace congestion and identifying more efficient routes, as well as the use of data analytics and digital solutions.

Air Traffic Management domain: Operational improvements to increase efficiency and reduce fuel burn

ATM initiatives offer a win-win solution for the environment, airlines, and passengers. Operational improvements to increase efficiency and the optimisation of flight routes can reduce track miles and flight durations. This enables airlines to reap fuel savings and for passengers to get to their destinations quicker, while reducing emissions. These benefits can be multiplied over many flights. CAAS will implement three initiatives over the next five years to improve ATM operations to increase efficiency and reduce fuel burn. Collectively, these initiatives are expected to bring about a 10% reduction in additional fuel burn and emissions. These include:

a) Advanced demand-capacity balancing implementation

CAAS will work with stakeholders to enhance the management of air traffic vis-à-vis available capacity, including improving coordination and management of longer-haul flights, as well as enhancing the reliability, timeliness, and accuracy of weather forecast information through the use of predictive tools to support decision making.

b) Performance-based navigation enhancement

CAAS will collaborate with partner Air Navigation Service Providers (ANSPs) in the region to implement more direct routings on a wider scale and in the longer-term, work towards introducing Free Route Airspace to bring about optimised

capacity and flexible flight trajectories. CAAS will also develop smart tools to facilitate the optimisation of descent flight profiles within Changi Airport which will help reduce fuel burn and emissions.

c) Gate-to-gate trajectory optimisation

CAAS is collaborating with stakeholders and partner ANSPs to work towards Trajectory-Based Operations. CAAS is also implementing a decision support tool to optimise the departure intervals between aircraft, which will enhance runway efficiency.

Critical Enablers: Build coalitions for action

The effective implementation of sustainability initiatives across the three domains will require strong government action and close collaboration with the industry. As such, key enablers are necessary for providing the right conditions for success. These include:

- a) Policy and regulation** are key instruments for the government to set the sustainability direction for the aviation sector and provide standardisation across the industry when required. CAAS has set domestic and international emissions reduction targets to spur the local aviation community to be more sustainable, including a national SAF target to encourage SAF production and kickstart adoption in Singapore.
- b) Industry development** is key in supporting the green transformation of the sector. To promote industry development, a S\$50 million Aviation Sustainability Programme (ASP) was established by CAAS in 2023 to fund sustainable aviation projects. The first call for proposals was conducted in April 2023 and a second call will take place in April 2024. CAAS has also set up an International Centre for Aviation Innovation (ICAI) to drive innovation partnerships and initiatives across all aspects of aviation including sustainability.
- c) Infrastructure planning and provision** is necessary for aviation sustainability initiatives to be implemented smoothly. CAAS, CAG, and other stakeholders will undertake important infrastructure planning to ensure future developments can achieve high sustainability standards. The new Terminal 5 is being designed and developed to achieve the Building and Construction Authority's (BCA) Green Mark Platinum Super Low Energy standard.
- d) Workforce transformation** is necessary for the aviation sector to achieve its sustainability initiatives. Through a tripartite effort, including the Singapore Government, companies, and unions, we will identify new and emerging sustainability-related job roles, accompanied by upskilling and job redesign

efforts supported by the National Trades Union Congress' (NTUC) Company Training Committees, relevant lifelong learning and skills-upgrading initiatives under SkillsFuture Singapore (SSG), and Workforce Singapore's (WSG) Career Conversion Programme. CAAS will also work with Institutes of Higher Learning to embed aviation sustainability resources and content into the curriculum and stimulate interest through sustainability-linked internships and learning journeys.

- e) **International partnerships and collaborations.** Singapore can play an important role as pathfinder and convenor for international collaborations and partnerships to advance sustainable aviation. For example, Singapore has forged agreement on an ASEAN Sustainable Aviation Action Plan (ASAAP), which is a ten-year plan that will detail milestones and activities to drive sustainable aviation growth in ASEAN. To better address the Asia-Pacific region's unique circumstances, CAAS will work with partners to establish the Asia-Pacific sustainable aviation centre to develop capabilities for sustainable aviation policy research specific to the needs of the Asia-Pacific region. This includes building deeper scientific understanding of regional SAF feedstocks, validating prevailing policy recommendations against the region's context to add new perspectives, and providing capacity-building activities for countries and companies.

In developing the Blueprint, CAAS has incorporated and built upon the recommendations by the International Advisory Panel (IAP) on Sustainable Air Hub, published in September 2022. The IAP was formed in February 2022, bringing together 20 industry, technology, and knowledge partners from Singapore and around the world. The IAP was chaired by Professor Chong Tow Chong, President of Singapore University of Technology and Design. Members of the IAP include Directors-General from key aviation International Organisations, as well as C-suite aviation industry executives and renowned knowledge and technology partners. To canvass ideas from a wider array of stakeholders, the IAP engaged more than 120 representatives from 40 local and international partners. Following the submission of the IAP recommendations, CAAS conducted extensive consultations with stakeholders and detailed studies before finalising the targets and initiatives of the Blueprint.

The Singapore Sustainable Air Hub Blueprint is part of CAAS's strategy post-COVID-19 to make the Singapore air hub more competitive, resilient, and sustainable.