Australian Government

Department of Infrastructure, Transport, Regional Development, Communications and the Arts

Western Sydney International (Nancy-Bird Walton) Airport – Airspace and flight path design

Environmental Impact Statement

Technical paper 3: Greenhouse gas emissions

October 2024

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Terms and abbreviations

Term/abbreviation	Definition
A41	41st Assembly (ICAO)
ABS	Australian Bureau of Statistics
A-CDM	Airport-Collaborative Decision Making
ACI	Airports Council International
ACP	Airspace Change Proposal (Airservices)
AEDT	Aviation Environmental Design Tool (US FAA)
AEED	Aircraft Engine Emissions Databank (ICAO)
ALC	Airport Lessee Company (WSA – the operator of WSI)
ANSP	Air Navigation Service Provider (i.e., Airservices)
APU	Auxiliary Power Unit (aircraft)
AR6	Sixth Assessment Report (IPCC, August 2021)
ARP	Aerodrome Reference Point (ICAO)
ATAG	Air Transport Action Group
ATM	Air traffic movement
BoM	Bureau of Meteorology (Australia)
CAEP	Committee on Aviation Environmental Protection (ICAO)
CANSO	Civil Air Navigation Service Organization
CASA	Civil Aviation Safety Authority (Australia)
CC Act	*Climate Change Act 2022* (Cth)
C-D	Climb-Descent (all phases of flight below 10,000 ft)
CCD	Climb, Cruise, Descent (all phases of flight from origin to destination)
CCO	Continuous Climb Operation
CCS	Carbon capture and storage
CDO	Continuous Descent Operation
CER	Clean Energy Regulator (Australia)
CO_2	Carbon dioxide (one of the Kyoto/UNFCCC defined greenhouse gases)
CO_2e	Carbon dioxide equivalents
COP	Conference of the Parties (UNFCCC)
CORSIA	Carbon Offsetting Reduction Scheme for International Aviation (ICAO)

Term/abbreviation	Definition
CST	Clean Skies for Tomorrow (WEF initiative)
COVID-19	Coronavirus 2019 (pandemic)
CSIRO	Commonwealth Scientific and Industrial Research Organisation (Australia)
Cth	Commonwealth of Australia
DAC	Direct air capture
DACCS	Direct air capture and carbon storage
DCCEEW	Department of Climate Change, Energy, the Environment and Water (Australian Government)
DIRD	(former) Department of Infrastructure and Regional Development (Australian Government)
DISER	Department of Industry, Science, Energy and Resources (Australian Government)
DITRDCA	Department of Infrastructure, Transport, Regional Development, Communications and the Arts (Australian Government)
EAP	Environment Assessment Package
EI	Emissions Index (CO_2)
EIS	Environmental Impact Statement
EPA	Environment Protection Authority (NSW Government)
EPBC Act	*Environmental Protection and Biodiversity Conservation Act 1999* (Cth)
FAA	Federal Aviation Administration (United States)
FMS	Flight Management System
ft	feet (unit of height equivalent to 0.3048 m)
GBMA	Greater Blue Mountains Area (World Heritage property)
GCD	Greater Circle Distance
GHG	Greenhouse Gas
GNSS	Global Navigation Satellite System
GSE	Ground service equipment (aircraft handling on the ground)
ha	hectare (unite of area equivalent to 10,000 m^2)
IACAC	International Aviation Climate Ambition Coalition (COP26)
IATA	International Air Transport Association (airline trade association)
ICAO	International Civil Aviation Organization (UN)
IEA	International Energy Agency (OECD)
IFR	Instrument Flight Rule

Term/abbreviation	Definition
IPCC	Intergovernmental Panel on Climate Change (UN)
ISO	International Standards Organization (independent, non-governmental)
kg	kilogram (unit of weight equivalent to 2.2046 pounds)
km	kilometre (unit of distance equivalent to 1,000 m)
kt	knot (unit of speed equivalent to 1.852 km/h)
KTP	Key Threatening Process (EPBC Act) (Cth)
LET	Low emissions technology
LGA	Local Government Area
LL	Low Level (altitude for transit flights through Sydney Basin))
LPLD	Low power, low drag
LTAG	Long-Term Aspirational Goal (ICAO)
LTCG	Long-Term Carbon Goal (ACI)
LTERP	Long Term Emissions Reduction Plan (Australia)
LTO	Landing take-off (cycle) (all phases of flight below 3,000 ft)
LULUCF	Land use, land use change and forestry (UNFCCC)
m	metre (unit of distance or height equivalent to 3.281 ft)
MAP	Million Annual Passengers
MBM	Market-based Measure (ICAO, CORSIA)
MNES	Matters of National Environmental Significance (EPBC Act) (Cth)
MRO	Maintenance, Repair and Overhaul (activities)
MRV	Monitor, Report, Verify (GHG emissions management)
Mt	million tonnes
MTOW	Maximum Takeoff Weight (aircraft)
NBJ	Narrow-body jet (single aisle aircraft)
NDC	Nationally Determined Contribution (under the Paris Agreement)
NGER Act	*National Greenhouse and Energy Reporting Act 2007* (Cth)
NGER	National Greenhouse and Energy Reporting (scheme - Australia)
NJ	Non-jet (aircraft type)
NIR	National Inventory Report (Australian Greenhouse Gas Accounts)
nm	nautical mile (unit of distance equivalent to 1.852 km)
NS	Northern Summer (IATA definition)

Term/abbreviation	Definition
NSW	New South Wales (state of Australia)
NW	Northern Winter (IATA definition)
OEM	Original Equipment Manufacturers
PAAM	Plan for Aviation Airspace Management
PBN	Performance Based Navigation
PMST	Protected Matters Search Tool (DCCEEW for MNES under the EPBC Act (Cth))
ppm	parts per million
PtL	Power to liquid (SAF-type)
RAAF	Royal Australian Air Force
RCP	Representative Concentration Pathway (IPCC)
RFI	Radiative Forcing Index
RMO	Runway Mode of Operation
RNP	Required Navigation Performance (air navigation procedure)
RNP AR	Required Navigation Performance (Authorization Required)
RPT	Regular Public Transport (air service)
RRO	Reciprocal Runway Operations (head-to-head mode of operation)
SAF	Sustainable Aviation Fuels
SAP	State Action Plan (Australian Government voluntary report to ICAO)
SID	Standard Instrument Departure (flight path)
SOE	State of the Environment (NSW state government report)
STAR	Standard Instrument Arrival (flight path)
t	tonne (unit of weight equivalent to 1,000 kg)
TIM	Time in mode (minutes: seconds)
TMA	Terminal Area
TP	Turbo-prop (aircraft type)
TWG	Technical Working Group (advisors to the DITRDCA)
UN	United Nations
UNFCCC	United Nations Framework Convention on Climate Change
VFR	Visual Flight Rule
WBCSD	World Business Council for Sustainable Development
WBJ	Wide-body jet (twin aisle aircraft)

Term/abbreviation	Definition
WEF	World Economic Forum
WRI	World Resources Institute (global research, non-profit organization)
WSA	Western Sydney Airport Company Limited (the operator of WSI)
WSI	Western Sydney International (Nancy-Bird Walton) Airport

Key messages

Summary of key findings:

- The modelling and assessment of estimated projected tailpipe emissions of carbon dioxide equivalents (CO_2e) in the engine exhaust behind aircraft is associated with the preliminary airspace design (flight paths and airspace structure) of Western Sydney International (Nancy-Bird Walton) Airport (WSI), which forms the second part of a 4-phase airspace development process. The preliminary airspace design will then be subject to formal community and stakeholder consultation. Feedback received will then be considered and used to inform the final design of the flight paths that are required for single runway operations at WSI.
- The combustion or burning of jet fuel (kerosene) emits various gases and particles referred to as greenhouse gases (GHGs). For a single, comparable value of GHG emissions, the total emissions of all emitted gases are converted to CO_2-equivalent[1] (CO_2e). CO_2 accounts for approximately 70 per cent of the exhaust[2]. The amount of GHG emitted in the exhaust behind aircraft engines use is directly related to the amount of fuel consumed.
- GHGs trap heat in the atmosphere. Key contributors include carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), and fluorinated gases. Reducing GHGs could limit average global temperature rise to a level that would prevent dangerous interferences with the climate system.
- The modelling of tailpipe CO_2e emissions in the engine exhaust behind aircraft operating in phases of flight below 10,000 feet (ft) or 3,048 metres (m) for all arrivals and departures used the Aviation Environmental Design Tool (AEDT). This is an internationally recognised aircraft noise and emissions calculation program developed by the United States Federal Aviation Administration (US FAA). Other methods prescribed under the Airports Council International's (ACI) *Airport Carbon Accreditation* programme and the International Civil Aviation Organization's (ICAO) Carbon Emissions Calculator were used to calculate emissions from all flights departing WSI to each destination airport across WSI's anticipated route networks in 2033 and 2055.
- Consideration was given to applicable international, Australian and NSW GHG emissions policy context along with various measures to manage GHG emissions from aircraft using WSI's flight paths.
- A separate paper (Technical paper 2: Air quality (Todoroski Air Sciences 2023)) (Technical paper 2) deals with air quality at the local, regional and national scales, levels of oxides of nitrogen (NOx), hydrocarbons (HC), reactive organic compounds, ozone (O_3), sulphur dioxide (SO_2), carbon monoxide (CO), odours, air toxics and ultrafine particles. Emergency fuel dumping (jettisoning) is covered in Technical paper 2 and also Technical paper 4: Hazards and risks (Eddowes Aviation Safety 2023) (Technical paper 4).
- The estimated CO_2e projections for WSI flight departures to domestic destination airports in 2033 and 2055 were compared to historical economy wide CO_2e emissions reported by the Australian and NSW Governments in 2019, including the transport sector and commercial aviation activities. Projections have also been considered by the Australian and NSW Governments and made in this assessment to compare against WSI's estimated aircraft tailpipe CO_2e emissions from domestic flight departures in 2033 and 2055. The projections of aircraft tailpipe CO_2e emissions for flight operations using WSI's flight paths below 10,000 ft (3,048 m) would emit around 128,778 tonnes of CO_2e (tCO_2e) in 2033. These emissions have been projected to increase to 441,935 tCO_2e in 2055. This increase is the result of 38 new destinations being added to WSI's route network, many of which would be mostly operated by large, twin-aisle wide-body jets (WBJ).
- The percentage proportion of WSI's projected CO_2e emissions of total CO_2e emissions projected for domestic aviation activities in NSW are estimated to be 0.04 per cent in 2033 increasing to around 0.2 per cent in 2055 in line with population growth and decarbonisation trends in other sectors.

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1 It is accepted industry practise to apply a "carbon dioxide equivalent" or "CO_2e" - a term for describing different GHGs in a common unit. For any quantity and type of GHG, CO_2e signifies the amount of CO_2 which would have the equivalent global warming potential.

2 United States of America, Environmental and Energy Study Institute

- The percentage proportion of WSI's projected aircraft tailpipe CO_2e emissions of total economy wide CO_2e emissions projected for Australia are estimated to be around 0.13 per cent in 2033 increasing to around 0.5 per cent in 2055.
- RPT services to medium and long haul destinations are the most carbon-intensive flights. They account for only a quarter of air traffic movements but are expected to be responsible for more than half of all full flight departure emissions of CO_2e. This is because these flights are operated by large WBJs that are required to carry and use more fuel (and emit more CO_2e) to transport passengers and belly-hold freight.
- Emissions of CO_2e from domestic commercial aviation activities are projected to grow steadily as aviation activity continues to grow in line with population growth.
- On an economy wide basis, the CO_2e emissions from WSI are small. In the years to 2040, these CO_2e emissions are unlikely to make material difference in the physical risk of future climate change projections, as historic CO_2e emissions have already been locked in global warming over this timeframe. Beyond this date to 2055, WSI's CO_2e emissions may marginally contribute to potential climate change but not at a level expected to inhibit Australia's commitment to emissions reduction targets made under the Paris Agreement or a transition to a net zero emissions economy by 2050.
- The outcomes from this technical paper are considered conservative as future air traffic management improvements, new aircraft and propulsion technology developments and fuel efficiency gains through scaling the production and use of sustainable aviation fuels (SAF) as well as the emergence of hydrogen have not been assessed.
- The benefits, in terms of CO_2e emissions savings, associated with improved operations, new aircraft technology and fuel measures (SAF) are expected to result in potentially substantive reductions of aircraft tailpipe CO_2e emissions projected for WSI in 2033 and in 2055.
- The future decarbonisation of domestic commercial aviation activities in Australia relies on solutions like SAF and advancements in aircraft engine and propulsion system technologies to deliver significant reductions. Abatement of aviation industry's carbon footprint is relatively more difficult than other industries. As other sectors of the Australian and NSW economy decarbonise, domestic aviation's proportion of the total emissions budget is expected to increase due to the lag expected in new generation aircraft technologies and availability and uptake of SAF.
- Wide-ranging measures will be required to manage and reduce aircraft tailpipe CO_2e emissions. It will require a collaborative approach across all aviation stakeholders including airports (including Western Sydney Airport Company Limited, WSA Co, the airport lessee company who will operate WSI), Airservices Australia, the airlines, aerospace manufactures and fuel companies to help airports such as WSI operate with the lowest carbon footprint possible.
- These measures include: improvement in aircraft fuel efficiency, improvement in aircraft routing and handling, trial of new aircraft technologies and operational concepts, research in SAF and the establishment of aviation industry forums to share knowledge, experience and best practice opportunities.

Chapter 1 Introduction

This chapter provides an overview of the proposed airspace and flight path design for the Western Sydney International (Nancy-Bird Walton) Airport (WSI). This includes the background to WSI and its accompanying airspace and flight path design (the project) which impacts on the existing Sydney Basin airspace. It describes the key features and objectives of the project and identifies the purpose and structure of this this technical paper.

1.1 Western Sydney International (Nancy-Bird Walton) Airport

1.1.1 Background

In 2016, the then Australian Minister for Urban Infrastructure approved development for a new airport for Western Sydney, now known as the Western Sydney International (Nancy-Bird Walton) Airport (WSI), under the *Airports Act 1996* (Commonwealth). The site of the new airport (the Airport Site) covers approximately 1,780 hectares (ha) at Badgerys Creek, as shown in Figure 1.1. The Airport Site is located within the Liverpool local government area (LGA).

Following the finalisation of the *Western Sydney Airport – Environmental Impact Statement* (2016 EIS), the Western Sydney Airport – Airport Plan (Airport Plan) was approved in December 2016. The Airport Plan authorised the construction and operation of the Stage 1 Development. It also set the requirements for the further development and assessment of the preliminary airspace design for WSI. The Australian Government has committed to developing and delivering WSI by the end of 2026.

The 2016 approval provided for the on-ground development of Stage 1 Development of WSI (a single runway and terminal facility capable of initially handling up to 10 million passengers per year) utilising indicative ‘proof of concept’ flight paths. These flight paths, presented in the 2016 EIS demonstrated that WSI could operate safely and efficiently in the Sydney Basin. WSI will be a 24-hour international airport and will:

- cater for ongoing growth in demand for air travel, particularly in the rapidly expanding Western Sydney region, as well as providing additional aviation capacity in the Sydney region more broadly
- provide a more accessible and convenient international and domestic airport facility for the large and growing population of Western Sydney
- provide long term economic and employment opportunities in the surrounding area
- accelerate the development of critical infrastructure and urban development.

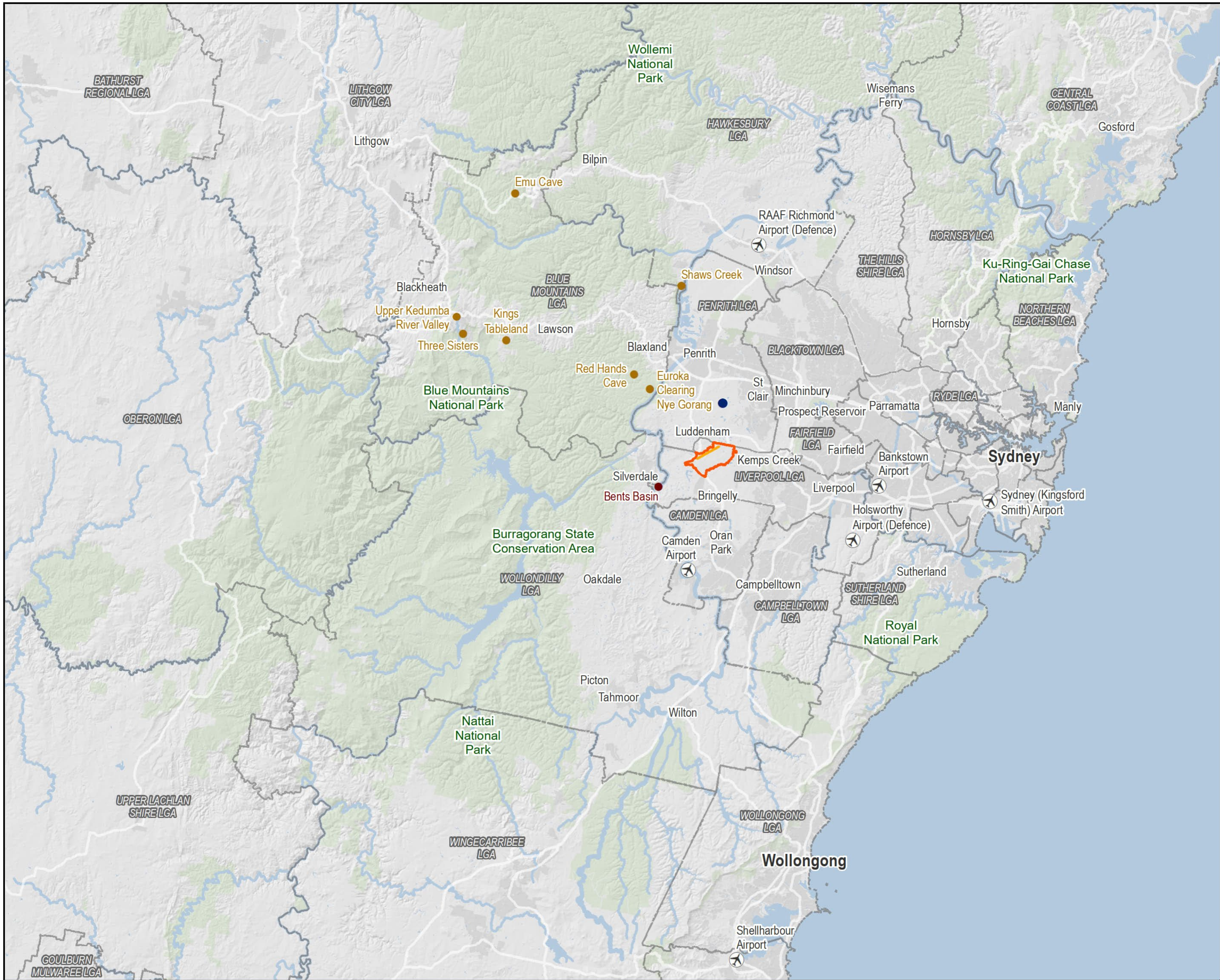
The Australian Government has committed to developing and delivering WSI by the end of 2026.

The design and assessment process for the next phase of the airspace design (referred to as the preliminary airspace design) was set by Condition 16 of the Airport Plan. This included the future airspace design principles and the establishment of an Expert Steering Group. Key to these design principles was the need to minimise the impact on the community and other airspace users while maximising safety, efficiency and capacity of WSI and the Sydney Basin airspace. The airspace design must also meet the requirements of Airservices Australia and civil aviation safety regulatory standards.

Led by the Australian Government Department of Infrastructure, Transport, Regional Development, Communications and the Arts (DITRDCA), the Expert Steering Group has developed the preliminary flight paths and airspace arrangements for WSI (the project). The preliminary airspace design is the subject of the EIS.

Figure 1.1

Regional Context of the Western Sydney International (Nancy-Bird Walton) Airport



Legend

- WSI Runway
- Western Sydney International (Nancy-Bird Walton) Airport land boundary
- State local government area (LGA)
- Orchard Hills Defence Establishment
- Aboriginal Places raised during consultation (NPW Act)
- Site of Aboriginal significance

0 10 20 km

Coordinate system: GDA 1994 NSW Lambert

Scale ratio correct when printed at A4

1:750,000 Date: 27/06/2023

Data sources: - DITRDC, DCS, Geoscience Australia
Esri, HERE, Garmin, (c) OpenStreetMap contributors, and the GIS user community
Airbus,USGS,NGA,NASA,CGIAR,NCEAS,NLS,OS,NMA,Geodatastyrelsen,GSA,GSI and the GIS User Community

1.1.2 The Airport

1.1.2.1 Stage 1 Development

The Stage 1 Development of WSI has been approved and is limited to single runway operations. It will handle up to 10 million annual passengers and around 81,000 air traffic movements per year by 2033 including freight operations (a movement being a single aircraft arrival or departure). Single runway operations are expected to reach capacity at around 37 million annual passengers and around 226,000 air traffic movements per year in 2055.

The approval provides for the construction of the aerodrome (including the single runway), terminal and landside layout and facilities, and ground infrastructure such as the instrument landing systems and high intensity approach lighting arrays. Construction of the Stage 1 Development commenced in 2018. Figure 1.2 shows location of the single runway within the Airport Site.

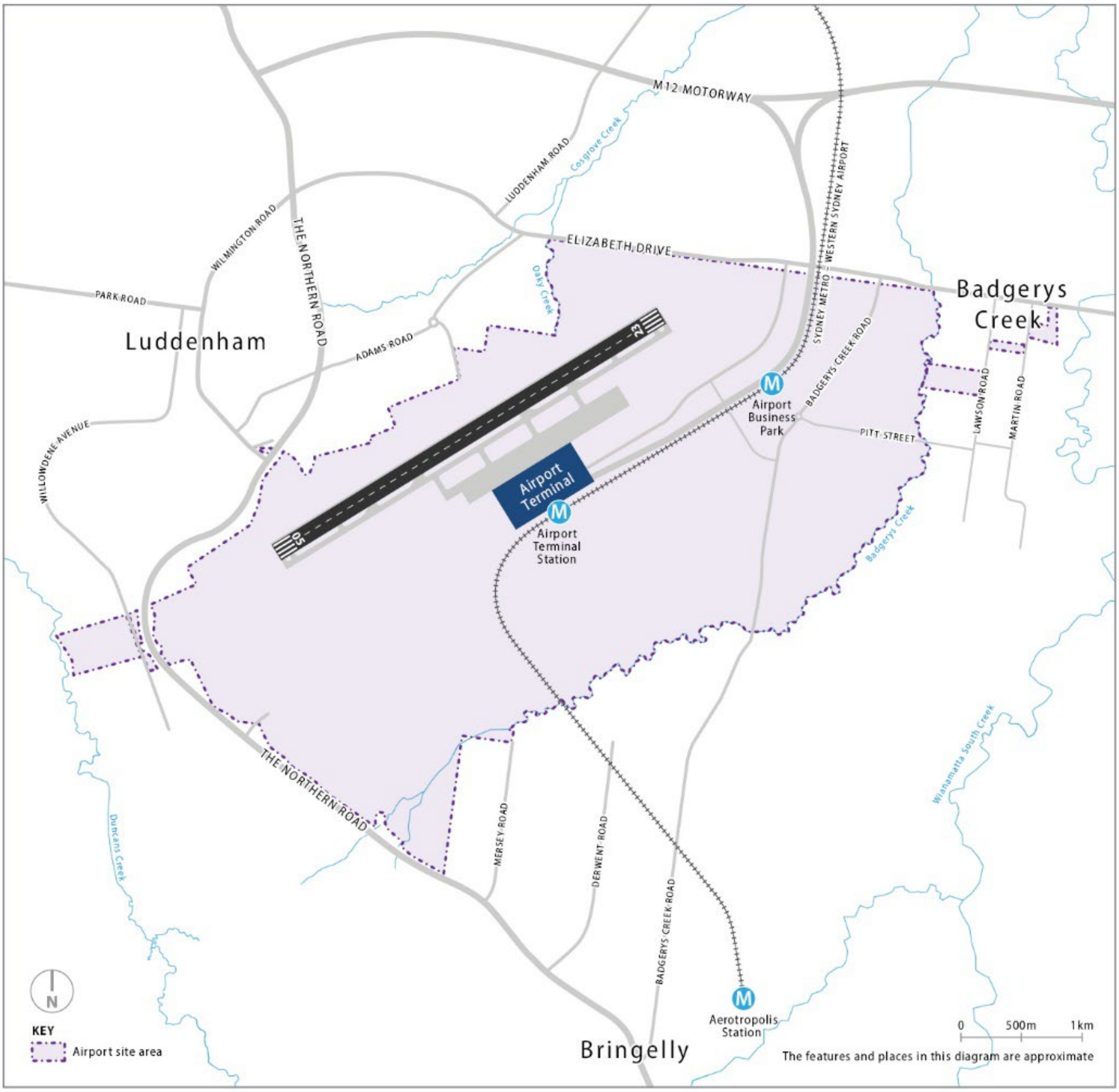


Figure 1.2 Western Sydney International Stage 1 Development

1.2 The project

The project consists of the development and implementation of proposed flight paths and a new controlled airspace volume for single runway operations at WSI. The project also includes the associated air traffic control and noise abatement procedures for eventual use by civil, commercial passenger and freight aircraft. The airspace and flight paths would be managed by the Air Navigation Services Provider (ANSP), Airservices Australia.

The project involves flight paths for all-weather operations on Runway 05 and Runway 23 during the day (5:30 am to 11 pm) and night (11 pm to 5:30 am), as well as head-to-head Reciprocal Runway Operations (RRO) during night-time periods (when meteorological conditions and low flight demand permit) to minimise the number of residences subjected to potential noise disturbance.

The flight paths differ during the day and night. Flight paths at night differ to take advantage of the additional airspace capacity offered when the curfew for Sydney (Kingsford Smith) Airport is in force. The proposed flight paths (as exhibited) are depicted in Figure 1.3 to Figure 1.7.

The project does not include any physical infrastructure or construction work.

Since the exhibition of the Draft EIS, refinements to the project have been incorporated into the preliminary flight path design. The final preliminary flight path design is presented in Chapter 7 (The Project) of the EIS.

1.2.1 Objectives of the project

The overall objectives for WSI are to:

- improve access to aviation services for Western Sydney
- resolve the long-term aviation capacity constraints in the Sydney Basin
- maximise the economic benefit for Australia by maximising the value of the Airport as a national asset
- optimise the benefit of WSI for employment and investment in Western Sydney
- deliver sound financial, environmental and social outcomes for the Australian community.

The project will assist in achieving these overall objectives as it would enable single runway operations to commence at WSI through the introduction of new flight paths and a new controlled airspace volume.

The Western Sydney Airport Plan sets out 12 airspace design principles that the design process is required to follow. The principles were informed by and reflect community and industry feedback on the 2016 EIS. The principles seek to maximise safety, efficiency and capacity, while minimising impacts on the community and the environment. For further information on the airspace design principles refer to Chapter 6 (Project development and alternatives) of the EIS.

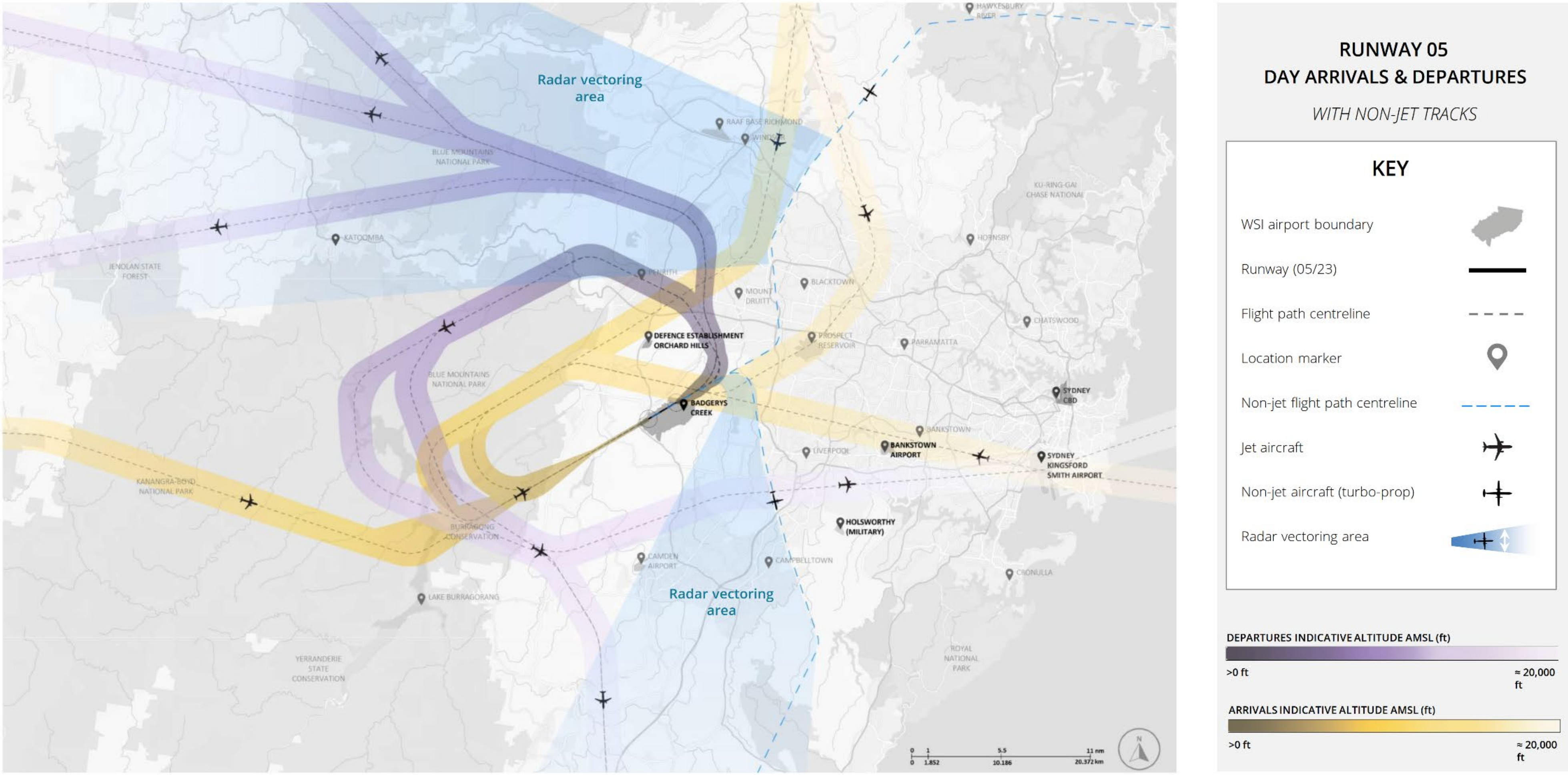


Figure 1.3 Proposed flight paths for Runway 05 (day)

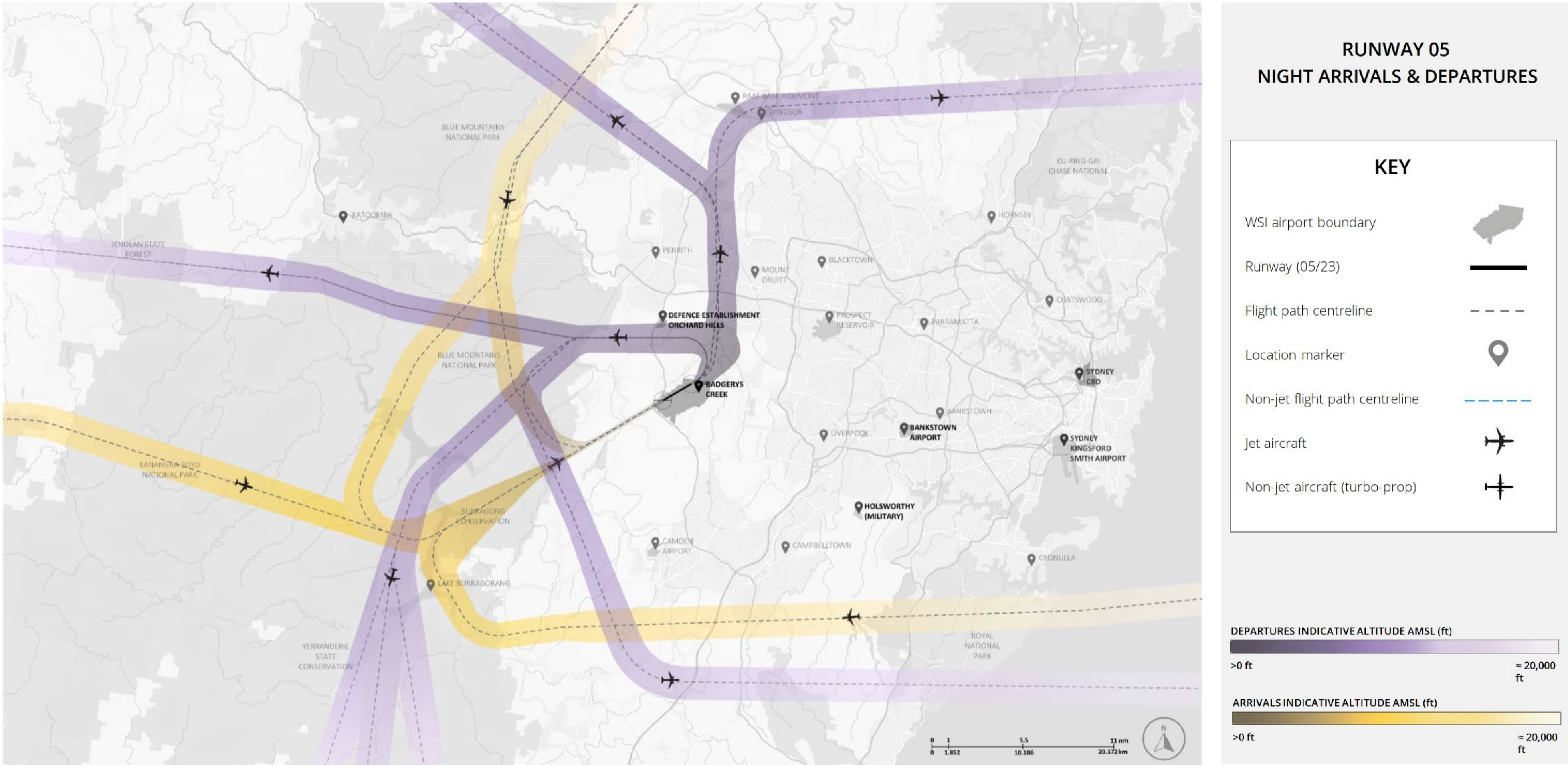


Figure 1.4 Proposed flight paths for Runway 05 (night)

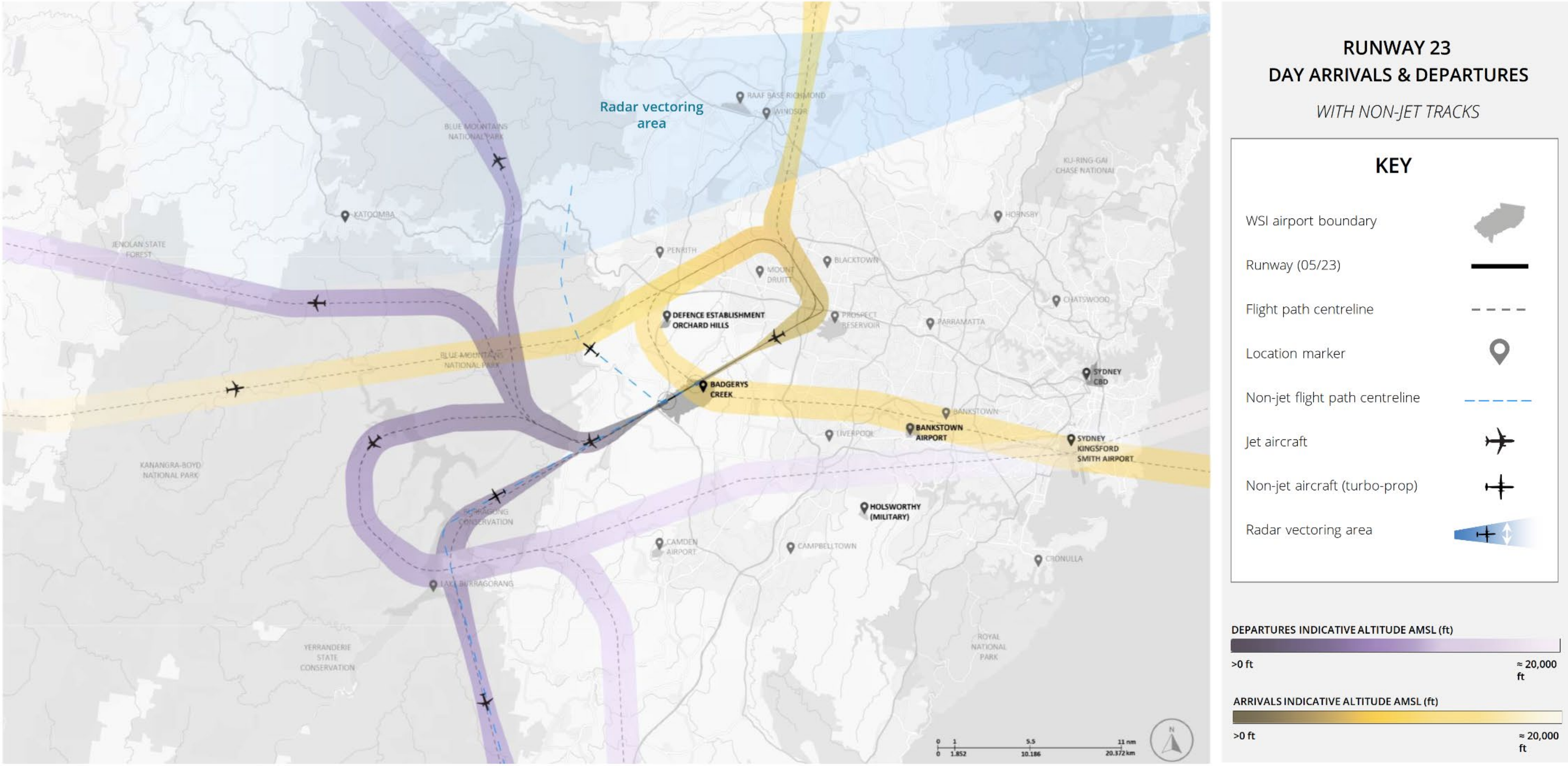


Figure 1.5 Proposed flight paths for Runway 23 (day)

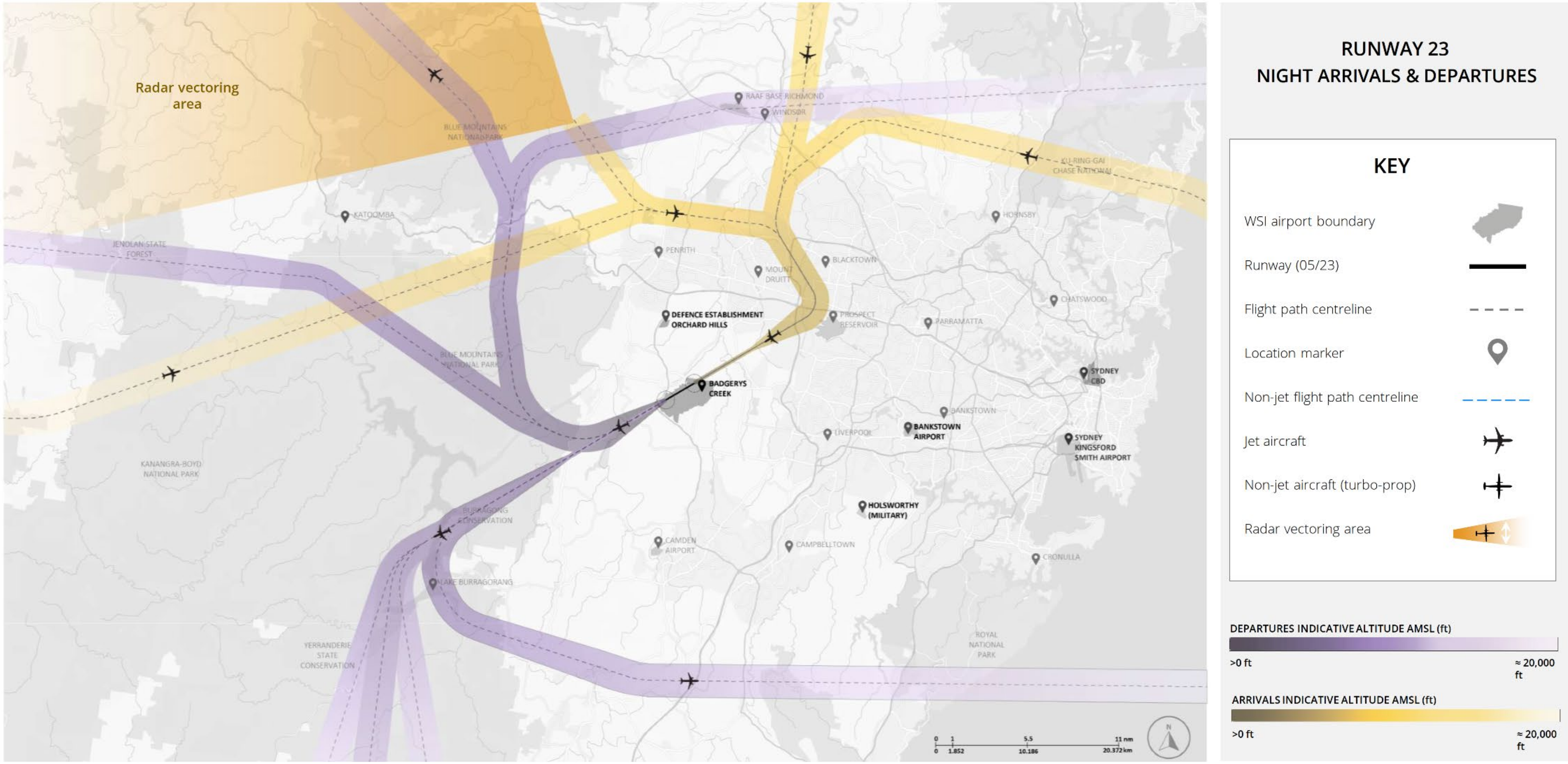


Figure 1.6 Proposed flight paths for Runway 23 (night)

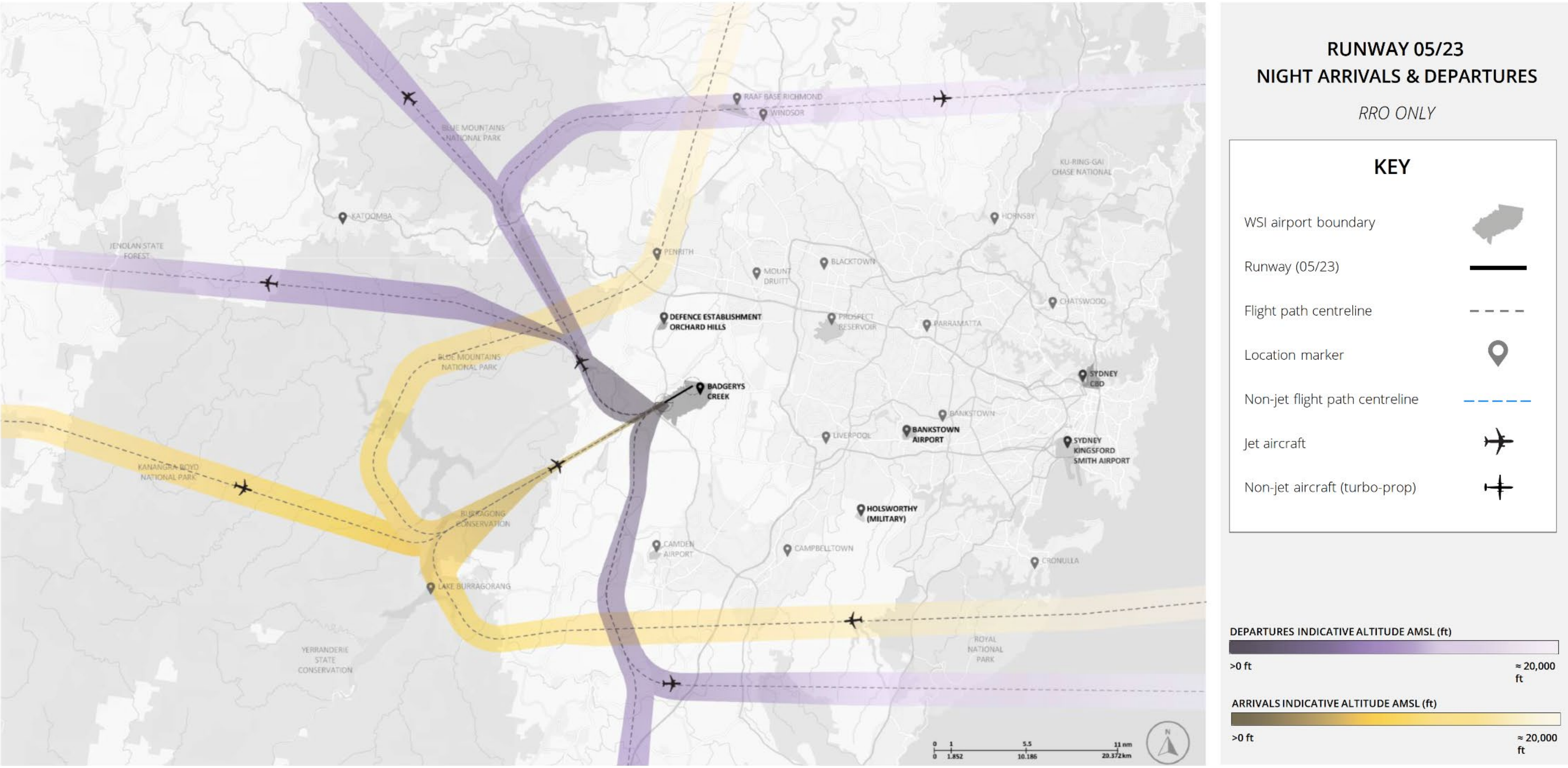


Figure 1.7 Proposed flight paths for Runway 05/23 (night)

1.3 Purpose of this technical paper

To address the potential impacts from aircraft that will operate along WSI's flight paths, this technical paper describes the existing economy wide greenhouse gas (GHG) emissions including emissions from commercial aviation activities in Australia and New South Wales (NSW) from aircraft engine operations in the Sydney Basin, applicable legislation and policy requirements, the potential impacts of WSI's flight paths and the methodology used to calculate tailpipe GHG emissions produced in the engine exhaust behind aircraft. Where required, this technical paper also identifies the specific measures that can be taken to avoid, manage, mitigate and/or monitor these impacts.

The purpose of this technical paper is to:

- explain the global air transport industry's role in the response to climate change and highlight global trends and outlooks, especially in relation to the achievement of net zero emissions by 2050, at the latest
- describe the relevant international, Australian and NSW legislative frameworks and policy, that form the context for the decarbonisation of aviation operations
- identify Matters of National Environmental Significance (MNES) under the Commonwealth (Cth) *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) (Cth) and determine the potential for significant GHG emissions impacts by the project within 45 nautical miles (nm) (around 83 kilometres (km)) of WSI
- set out the assumptions, methodology and technical limitations for the impact assessment, including establishment of the GHG emissions assessment boundary for aircraft operating along WSI's flight paths and route network only
- define the sources of GHG emissions associated with aircraft operating on WSI's flight paths and route network
- calculate the likely GHG emissions for aircraft arriving and departing WSI in 2033 and in 2055 below 10,000 ft (3,048 metres (m)) and for aircraft departing to destination airports across the anticipated WSI route network
- assess the potential impacts and climate risks associated with the projected GHG emissions from the operation of aircraft using WSI's airspace and flight paths
- identify measures to avoid, manage, mitigate and monitor these impacts.

As identified in Section 1.2, refinements to the project have been incorporated into the preliminary flight path design. The assessment of these changes has been presented in Chapter 24 (Refinements since exhibition of the EIS) of the Submissions Report and incorporated into the EIS.

1.3.1 Assessment requirements

This technical paper has been prepared as part of the EIS to document the process and outcomes of the assessment of potential GHG emissions from in-flight aircraft engine use. The assessment considers the impacts that may occur from aircraft using WSI's flight paths and air route network after opening in 2026. As the project involves the introduction of flight paths and operating procedures in a 3-dimensional volume of airspace in the Sydney Basin, likely the busiest and most complex airspace in Australia, this assessment is focussed exclusively on the GHG emitted in the engine exhausts behind aircraft operating along WSI's flight paths and route network from WSI to each destination airport.

Section 2.2.5 of the Airport Plan presents the 12 future airspace design principles that apply to the comprehensive design process for single runway operations at WSI. The relevant principles for this GHG emissions assessment are:

- **Principle 5** – aircraft arrivals will use a continuous descent approach where possible to keep aircraft at higher altitudes with low engine power (thrust) settings and reduced noise (and greenhouse gas) emissions.
- **Principle 12** – safety is non-negotiable – only practicable solutions that uphold Australia's long tradition of world-leading aviation safety will be implemented.

The assessment requirements for GHG emissions from aircraft engine use in the EIS Guidelines are summarised in Table 1.1 also identifies where each requirement has been addressed within this technical paper or other technical papers prepared as part of the EIS.

Table 1.1 GHG emissions assessment requirements from the Minister's EIS Guidelines (EPBC Act 2022/9143)

EIS Guidelines reference	Information required	Location in this technical paper
(7.5) Air Pollution	(7.5.1) Analyse and describe the contribution and impacts of the proposed action on air quality at the relevant local, regional and national scales, having regard to relevant weather characteristics including winds, fogs and temperature inversions and any topographic features which may affect the dispersion of air pollutants.	Not covered in this technical paper – refer to Technical paper 2.
	(7.5.1) Reference must be made to levels of oxides of nitrogen, hydrocarbons, reactive organic compounds, sulphur dioxide, carbon monoxide, odours, air toxics and ultrafine particles.	Not covered in this technical paper – refer to Technical paper 2.
	(7.5.1) Estimate greenhouse gas emissions and include a discussion on design and procedural measures to reduce such emissions. Provide context and comparisons to other sources at local, regional and national levels as appropriate.	Chapter 3 to Chapter 10 of this technical paper. AEDT was used to model GHG emissions from main engine use by aircraft operating in phases of flight up to 10,000 ft (3,048 m) and in full flight for aircraft departing to destination airports across the WSI route network. Consideration is given to applicable international, Australian and NSW GHG emissions policy context along with various measures to manage GHG emissions from aircraft using WSI's flight paths.
	(7.5.2) Detail emergency fuel dumping procedures, including designated locations for such contingencies, effects of weather conditions on fuel dumping locations, notification to emergency services of fuel dumping occurring, and effects of fuel dumping.	Not covered in this technical paper - refer to Technical paper 4.

Chapter 2 GHG emissions context

2.1 Introduction

An understanding of the principles of flight is important when considering the potential GHG emission impacts caused by the operation of aircraft engines during the different phases of flight. Aircraft wings are equipped with devices known as flaps, that can be extended and retracted to change the shape and size of the wing. This allows an aircraft to fly efficiently at high cruise speed and safely at low speed for landing and take-off. Sufficient engine power (thrust) to achieve speed through the air is another essential factor when considering the principles of flight.

For an aircraft to fly it must generate lift to overcome its weight. The generation of lift also produces drag, as does the movement of the airframe through the air. Drag is an impediment to an aircraft's forward motion. The combination of speed and wing shape produces lower pressure on the upper surface of the wing than the lower surface. The higher pressure on the bottom surface of the wing compared to the lower pressure on the top surface creates net upward force known as lift. The engines generate the thrust necessary to overcome drag and produce a speed where lift can occur. The greater the thrust required the more fuel is burnt and GHGs emitted.

GHGs are gases that trap heat in the atmosphere. Key contributors include carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), and fluorinated gases. Reducing GHGs could limit average global temperature rise to a level that would prevent dangerous interferences with the climate system. Water vapor is also a product of jet fuel consumption, making up about 30 per cent of the exhaust. The presence of water vapour in the exhaust plume from an aircraft has an indirect impact by contributing to the formation of contrails[3] (refer to Figure 2.1).

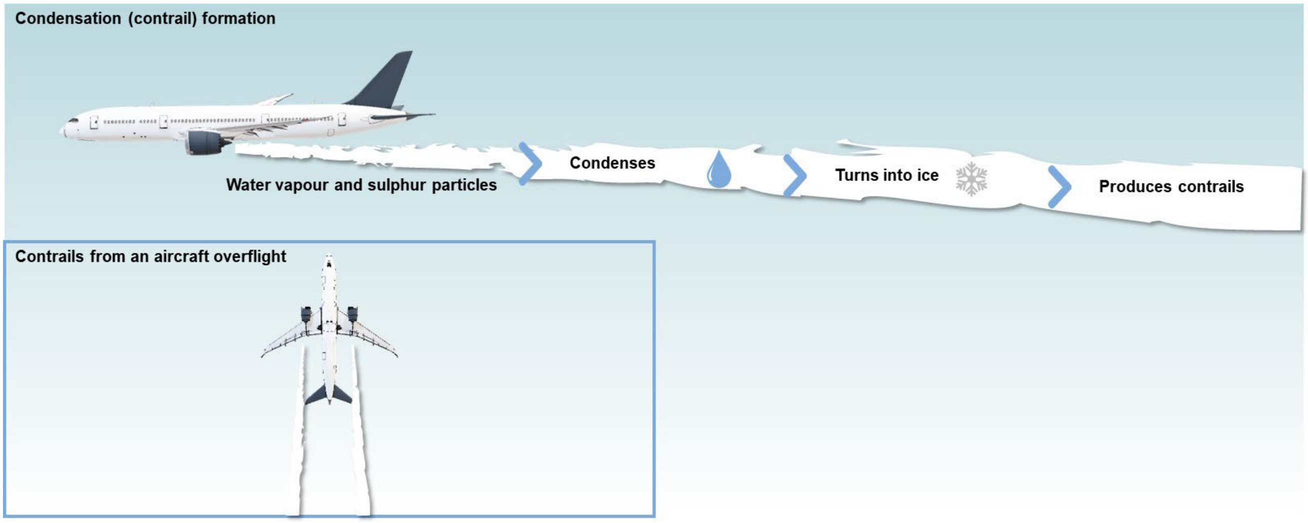


Figure 2.1 Condensation trail (contrail) formations (not to scale)

[3] Condensation trails (contrails) are white, cloud-like formations sometimes visible in the main engine exhaust behind jet aircraft, normally when cruising at altitudes above 26,000 ft where the air temperature is below 36.5 degrees Celsius. Contrails are temporary (the length of time is dependent on atmospheric conditions) and form behind an aircraft's engines in an expanding exhaust plume. They comprise a mix of gases emitted by jet aircraft in flight, including water vapour and sulphur particles.

The combustion or burning of jet fuel (kerosene) emits various gases and particles referred to as GHGs. For a single, comparable value of GHG emissions, the total emissions of all emitted gases are converted to CO_2-equivalent[4] (CO_2e). CO_2 is the largest component of aircraft GHG emissions, accounting for approximately 70 per cent of the exhaust. The amount of GHG emitted from aircraft main engine use is directly related to the amount of fuel consumed.

Figure 2.2 shows the relationship between aerodynamic forces and GHG emissions.

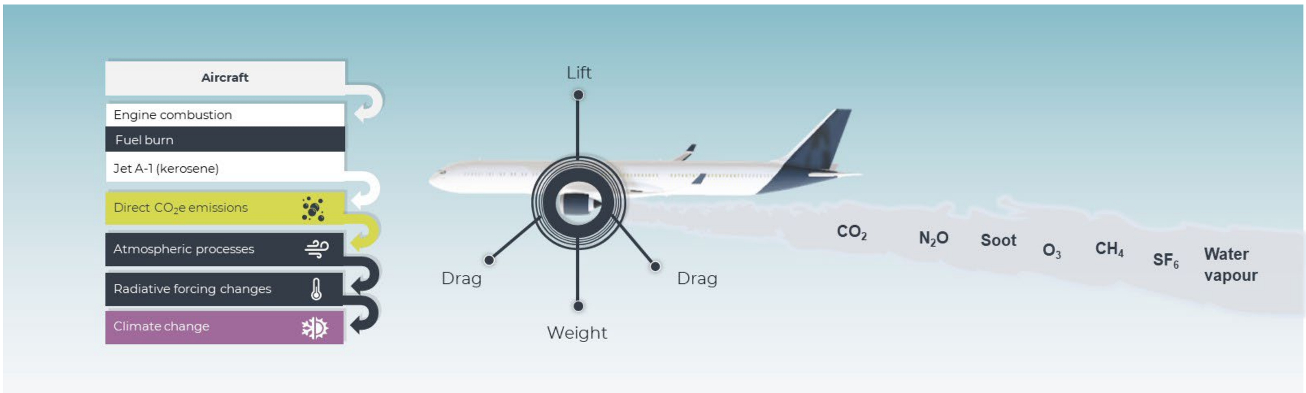


Figure 2.2 Aircraft aerodynamics and GHG emissions

Radiative forcing is a change in the balance of the sun's radiation reaching the earth, and heat leaving the earth from human-induced activities like aviation and natural factors. Changes in atmospheric GHG concentrations affect radiative forcing. A Radiative Forcing Index (RFI) is a multiplier used for GHG emitted to the atmosphere from aircraft flying at altitude (i.e., 26,000 ft (7,925 m) and above). When GHGs are emitted at altitude they result in more potential heating than if the same amount was emitted at sea level. This is because higher altitudes affect fuel combustion and GHG emission characteristics. There is currently no consistent recommendation on the use of RFI[5] values when calculating GHG emissions from aircraft flying at higher altitudes. For this assessment, a RFI will not be applied due to current uncertainties surrounding its application.

2.2 Baseline and reference year GHG emissions for aircraft engine use

An aircraft GHG emissions inventory was prepared for the use of flight paths by aircraft operating to/from WSI below 10,000 ft (3,048 m). A 2019 baseline (last busiest year before the coronavirus (COVID-19) pandemic) was established for GHG emissions from commercial aviation activities in Australia and NSW. This baseline relied on the GHG emissions reported in the Australian Greenhouse Accounts managed by the Australian Government Department of Climate Change, Energy, the Environment and Water (DCCEEW). The Australian Greenhouse Gas Accounts and National Inventory Reports (NIR) prepared by DCCEEW and submitted annually to the United Nations Framework Convention on Climate Change (UNFCCC) contain historical GHG emissions data reported by economic sector (including transport) and by each state and territory.

The difference between aircraft engine GHG emissions was considered for 2 Planned Activity Levels (PAL) in 2 assessment years:

- PAL 1 (2033, represents the early years of WSI operations)
- PAL 3 – (2055, represents the year when single runway operations are expected to be operating at near capacity).

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4 It is accepted industry practise to apply a "carbon dioxide equivalent" or "CO_2e" - a term for describing different GHGs in a common unit. For any quantity and type of GHG, CO_2e signifies the amount of CO_2 which would have the equivalent global warming potential.

5 ICAO/Environmental Protection/Carbon Emissions Calculator

Absolute and intensity based GHG emissions from aircraft main engine operations for regional, domestic and international Regular Public Transport (RPT) and freight services were estimated in each assessment year. Comparisons were also made to the historical economy wide GHG emissions reported for Australia and NSW in 2019 (Australian Greenhouse Gas Accounts) and projections of future GHG emissions out to 2035. These have been extrapolated further to 2055 based on growth projections made by the Australian Government (the then Department of Infrastructure and regional Development (DIRD) on commercial aviation activities (domestic and international) in Australia's State Action Plan (SAP) submitted to the International Civil Aviation Organization (ICAO) in 2017 (DIRD 2017).

The main sources of GHG emissions from aircraft occur from engine use during all phases of flight. In line with commonly accepted practice, this assessment projected the GHG emissions from aircraft engine use in 3 operating domains in 2033 and in 2055:

1. the Landing and Take-off (LTO) cycle[6] below 3,000 ft (914 m) above ground level.
2. an extended Climb and Descent (C-D) cycle below 10,000 ft (3,048 m) above ground level.
3. all flights to destination airports (full flight segments) across the anticipated WSI flight route network.

It is recognised that RPT and freight services are expected to constitute all WSI's aircraft flight operations and will generally operate at cruise altitudes greater than 30,000 ft (9 km). Climb and descent below 10,000 ft (3,048 m) is typically consistent with the extent of the Terminal Area (TMA), with further climb to the enroute network and cruise phase of flight normally operating at reduced engine power (thrust) settings.

2.3 Pathways to emissions reduction

Measures to deliver and manage GHG emissions reductions from aircraft engine operations require ongoing collaboration amongst airlines, Airservices, aircraft and engine manufacturers and Western Sydney Airport Company Limited (WSA Co – the Airport Lessee Company (ALC)). A description of several pathways to help the global air transport industry reach net zero emissions by 2050 is provided in Section 3.7 of this technical paper. Each pathway is significantly reliant on Sustainable Aviation Fuels[7] (SAF) to meet the global air transport industry's decarbonisation commitments.

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6 ICAO's Airport Air Quality Manual (Document 9889), Second Edition, 2020: https://www.icao.int/publications/Documents/9889_cons_en.pdf, "For emissions certification purposes, ICAO has defined a specific reference LTO cycle below a height of 914 m (3 000 ft) above ground level, in conjunction with its internationally agreed certification test, measurement procedures and limits (see Annex 16, Volume II, for additional information)".

7 According to the International Civil Aviation Organization (ICAO), sustainable aviation fuels (SAF) are defined as renewable or waste-derived aviation fuels that meet sustainability criteria. Technical analysis done at ICAO shows that SAF has the greatest potential to reduce CO_2 emissions from International Aviation.

Chapter 3 Aviation and climate change

3.1 Climate related risks to aviation

The existential threat of climate change is strengthening and remains the greatest long-term challenge facing global aviation. This is despite being eclipsed temporarily by the impact of the coronavirus (COVID-19) pandemic since early 2020 and the protracted and uncertain recovery that has followed.

Extreme weather continues to increase in frequency and severity amid rising global temperatures – the sheer scale of the Australian bushfires in early 2020, for instance, disrupted flights in Eastern Australia and forced the temporary closure of Canberra Airport due to the impact of smoke haze on visibility. In February and March 2022, severe weather and extensive flooding across Eastern Australia temporarily closed Gold Coast Airport and reduced Brisbane Airport to single runway operations. Runways and taxiways at both airports were inundated by floodwaters. This triggered mass flight cancellations and significant delays and staff shortages at both airports. Lismore Airport in Northern NSW was almost entirely submerged.

Large parts of Europe and the United Kingdom experienced extreme heat in July 2022. On 18 July 2022, Luton Airport, about 48 km north of London, had to temporarily suspend flights because the excessive heat (above 35 degrees Celsius) damaged part of its runway.

The effects of such events threaten to damage airport infrastructure, disrupting flight operations and utility networks and the business continuity of airports. If climate change continues unchecked it has the potential to cost airports, airlines, and passengers billions of dollars every year.

WSI will be an essential piece of regional and national infrastructure supporting the mobility and economic growth of the communities it serves, especially those in the Western Sydney Region and the Sydney Basin.

The operation of WSI must be capable of delivering high levels of availability, reliability and resilience in a changing climate that has the potential to disrupt aviation and business activity through physical and transitional risks. Adaptation and resilience to climate-related risks means that WSI must also consider economic and technological shifts, commodity dependencies and meteorological forecasts and climate science. Combined, these factors could disrupt global/local supply chains and transport logistics, especially where products are sourced from countries vulnerable to climate induced events. Shifts in energy supply and demand patterns are anticipated, as is the increased incidence of disaster and disease related to extreme weather. From March 2021 to April 2022 large parts of Western Sydney were inundated by major floodwaters causing widespread damage and destruction to thousands of homes and local infrastructure due to record levels of rainfall.

With more frequent extreme weather events expected for the Sydney Basin, WSI's airspace functionality, operation and performance could be susceptible to disruption from damage to infrastructure in and around the airport. Table 3.1 shows the main direct physical climate-related risks that WSI must address, along with the related impacts on flight schedules.

Table 3.1 Likely physical climate-related risks to WSI

Driver	Risk
Greater rainfall and storm frequency and intensity	Temporary airside disruptions due to flooding and damage on airport, especially the airfield and single runway system (05/23) causing flight delays and cancellations. Temporary landside disruption due to flooding and damage to Greater Sydney metropolitan transport infrastructure affecting air traffic controllers, passengers, and airline/airport staff from accessing WSI. Temporary disruption to flight schedules from convective weather and stormy conditions, especially lightning suspending aircraft ground handling and refuelling and changes to flight routing (holds or diversions).
Higher temperatures and more severe heatwaves	Restricted aircraft payloads (freight and seat capacity) from adjusted Maximum Take-off Weight (MTOW) where temperatures regularly exceed 35 degrees Celsius (exacerbated during periods of high humidity) due to reduced aerodynamic lift for departing aircraft from 'thin air' creating conditions conducive to sub-optimal climb and engine performance. Increased cost and temporary disruption to airside and landside power supply due to increased energy demand during heatwaves potentially affecting critical air traffic management infrastructure required to move aircraft safely and efficiently through WSI's airspace and wider Sydney Basin airspace. Surface and subsurface damage to pavements (i.e., cracking, lifting, melting) due to heat exposure above design standards resulting in flight delays and cancellations if the runway (05/23) is impacted. Increased presence of bats and birds, including migratory birds, increasing the risk of wildlife-strike due to increased rates of plant growth from longer summer seasons. Increased bushfire risk accompanied by periods of drought or low precipitation resulting in flight delays due to low visibility and hazardous flying conditions.
Changes to prevailing winds and higher wind speeds	Reduced runway utilisation and schedule delay due to changes in wind direction and speeds causing flight disruptions from crosswinds and tailwinds. Increased wind speed which creates increased crosswinds (both in speed and frequency) can lead to a decrease in aircraft controllability and stability during landing and take-off due to requirements for longer take-off distances and greater potential for go-arounds and missed approaches causing flight delays.

The Intergovernmental Panel on Climate Change's (IPCC) Special Report, published in October 2018,[8] called for drastic reductions in global carbon emissions. This claim was supported by scientific evidence which project significant differences in climate-related risks between 1.5–2-degrees Celsius warming and the resulting change to global and regional climate systems. Pathways to limit global warming to 1.5 degrees Celsius will require accelerated and profound transformations in energy, infrastructure, transport and industrial systems.

According to the IPCC, average global temperatures have risen by 1.1 degrees Celsius since the pre-industrial period (1850-1900). Leading climate and scientific organisations in Australia have concluded that land temperatures have risen by about 1.47 degrees Celsius since records began in 1910. This means Australia is highly vulnerable to the predicted effects of climate change. Evidence of this is supported by the unprecedented bushfires, floods, droughts, storms, heatwaves and significant ecosystem dieback (gradual deterioration of ecosystem health) in response to the permanency of rainfall and temperature changes.

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8 IPCC, October 2018: Global Warming of 1.5°C. An IPCC Special Report on the impacts of 1.5°C above pre-industrial levels and related greenhouse gas emission pathways (IPCC, Special Report, 2018).

Figure 3.1 has been adapted from the Mercator Research Institute on Global Commons and Climate Change to show the current state of global (cumulative) carbon emissions and temperature rise.

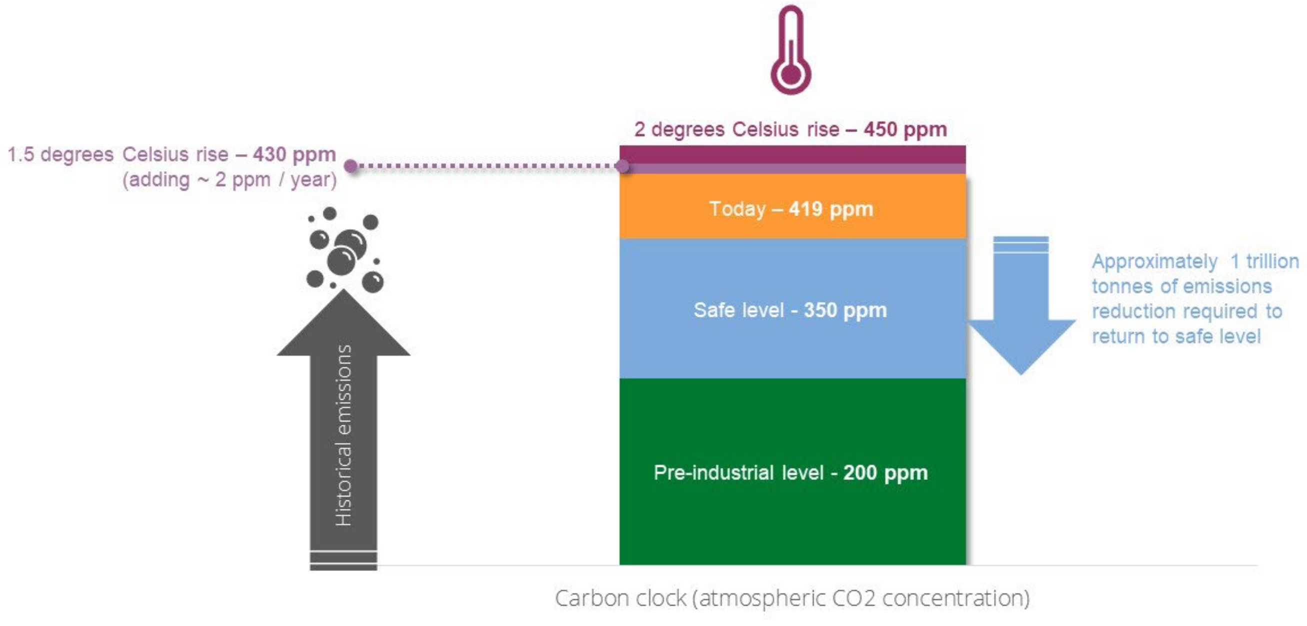

Figure 3.1 Global carbon emissions and average temperature rise

3.2 Aviation's climate action framework

In 2019, the International Air Transport Association (IATA) estimated that global aviation CO_2e emissions were 915 million tonnes (Mt CO_2e). Around 80 per cent of these emissions were attributed to RPT services (732 Mt CO_2e), with the remainder due to freight services. By comparison, in 2019 aviation CO_2e emissions in Australia were estimated by the DITRDCA[9] to be almost 24 Mt CO_2e representing around 2.5 per cent of the global aviation industry total. Rising to the challenge while grappling with the aftermath of theCOVID-19 pandemic crisis, the global aviation industry has responded by aligning their carbon management programs to the UNFCCC's Paris Agreement[10] objective to pursue efforts to limit average global temperature rise to 1.5 degrees Celsius above pre-industrial levels, relative to 1850–1900[11]. Many airlines, airports and ANSP organisations worldwide have pledged to reach net zero[12] by 2050 (at the latest) to avoid the worst climate outcomes. Ambitious targets are in place and significant investment committed to decarbonise activities under their direct control and ownership. They are also working closely with industry partners and supply chains to reduce and eliminate carbon emissions from their activities. These commitments are now embedded into corporate strategy, enterprise risk management frameworks, capital investment programs, financial and non-financial performance reporting of leading organisations in the aviation industry.

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9 DITRDCA, October 2022, Australia's State Action Plan – International Civil Aviation Organization (ICAO) Assembly Resolution A37-19 on Climate Change

10 Adoption of The Paris Agreement Decision 1/CP21.

11 Article 2.1(a) of the Paris Agreement states the goal of "Holding the increase in the global average temperature to well below 2°C above pre-industrial levels and pursing efforts to limit the temperature increase to 1.5°C above pre-industrial levels.

12 Net zero emissions is a step beyond carbon neutrality, as the term applies to the full scope 1, 2 and 3 emissions. In best practice, net zero (as defined by SBTi) involves the maximum feasible reduction of emissions (90 per cent physical absolute reduction across all scopes by 2050 at the latest for cross-sector pathway), with goals aligned to a 1.5 degrees Celsius science-based target. It also includes the removal of remaining GHGs with carbon removals. Although offsetting can play a subsidiary role, it should be complementary to real reduction.

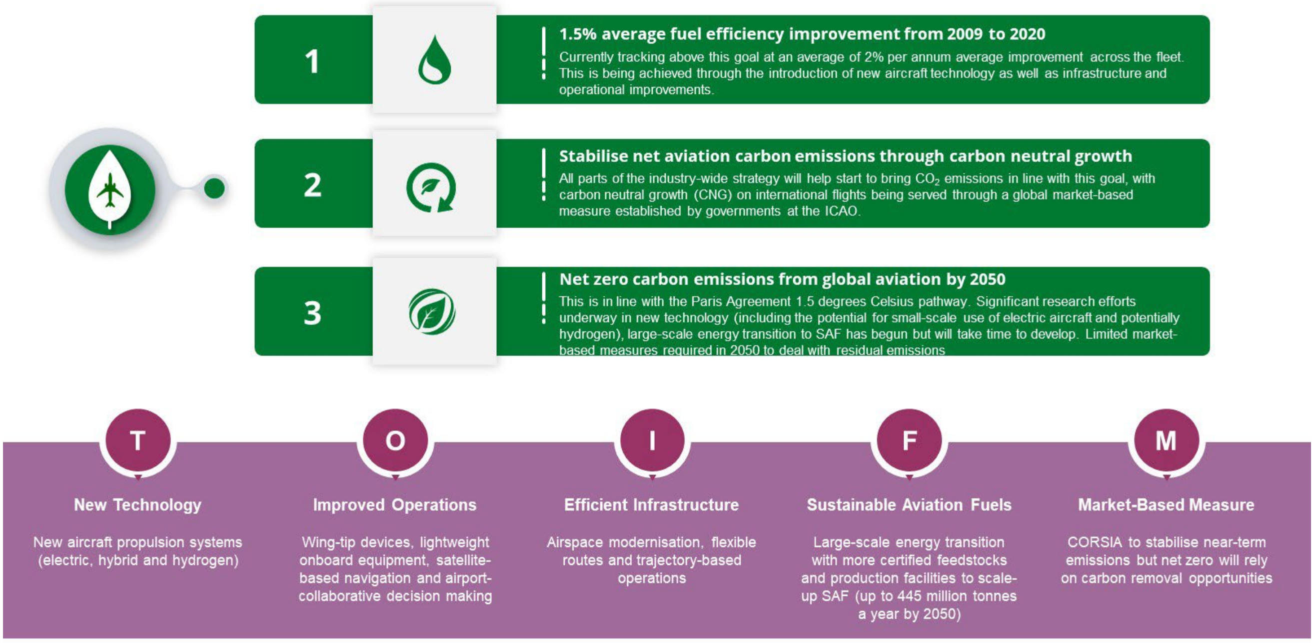
Nonetheless, the range of decarbonisation technologies in the market is limited, and what's available is expensive.

The worsening effects of climate change have made decarbonisation a top priority for many industries, including global aviation. According to the IPCC, global aviation is responsible for between 2–3 per cent of total current global human-induced carbon emissions. While this percentage of carbon emissions from aviation has not changed significantly since 1992, aviation's share of global emissions is expected to increase as traffic grows and other sectors decarbonise. Concern about aviation's impact on the climate continues to intensify and dominate the policy agenda and public debate, reinforcing the importance of deeper and accelerated emissions cuts and continued investment.

The Conference of the Parties (COP) 21st meeting of the UNFCCC in Paris in 2015 agreed to significant global action on climate change. Over 195 national participants signed the Paris Agreement, committing to limit average global temperature increase to 2 degrees Celsius above pre-industrial levels, with an aspirational target to limit this temperature increase to 1.5 degrees Celsius. Since the signing of the Paris Agreement, national actions to reduce carbon emissions around the world have ramped up.

The global aviation industry has taken an ambitious, collaborative and proactive approach to tackling its climate change impact. Decisive action is being taken by aviation in Australia and internationally to operate the sector sustainably to help attempting to limit the rise in global temperature to 1.5 degrees Celsius. The risk to aviation of inaction is not just limited to public opposition to growth, airport expansion and "flight shaming"[13]. No one will fly to cities or holiday destinations that are under water, oppressively hot or subjected to more frequent extreme and unpredictable weather.

In 2009[14], the world's major aviation industry associations including the Airports Council International (ACI), the Civil Air Navigation Service Organization (CANSO), the IATA, the International Business Aviation Council (IBAC) and others, launched an initial set of short-, medium- and long-term goals to address its climate impact – one of the first industries to do so at a global level. This set out a framework for collaborative action across the industry: airlines, airports, ANSP organisations and manufacturers of aircraft, engines and other components. These goals and the industry-wide strategy underpinning them are shown in Figure 3.2.



Source: Adapted from the International Aviation Industry's three global climate goals and four pillar strategy to reduce the impact of aviation on climate change and set an ambitious agenda of coordinated global action

Figure 3.2 Global aviation's 3 climate goals, industry-wide emissions reduction strategy

[13] In 2018, the term *"flygskam"* emerged in Sweden. *Flygskam* or flight shame relies on making people uncomfortable to fly (or those air travellers who continue to fly) when knowing the climate-damaging consequences of their journey.

[14] IATA, Fact Sheet 4: Strategic Direction - The Wedge Chart

3.3 The *Airport Carbon Accreditation* Programme

Developed and launched by ACI EUROPE initially for European airports in 2009, *Airport Carbon Accreditation*[15], went global in 2014. *Airport Carbon Accreditation* is the only voluntary global carbon management standard for airports. It provides a common framework for active carbon management and relies on internationally recognised methodologies, including the GHG Protocol[16] and ISO14064-1:2018 to independently assess and recognise the efforts of airports to manage and reduce their carbon emissions. Airports can become accredited at 6 progressively ambitious levels of accreditation:

- Level 1 Mapping level (1)
- Level 2 Reduction level (2)
- Level 3 Optimisation level (3)
- Level 4 Transformation.

Airports accredited at Level 3 and Level 4 can choose to offset their residual emissions, thereby achieving Level 3+ Neutrality and Level 4+ Transition respectively (refer to Figure 3.3).

Fourteen Australian airports currently participate in the *Airport Carbon Accreditation* programme (refer to Figure 3.4). Adelaide and Melbourne Airports and Sydney (Kingsford Smith) Airport are all currently accredited at the Optimisation level (3). To maintain accreditation at this level these airports are required to engage and work closely with their partners especially the airlines and freight operators to reduce GHG emissions while also actively measuring performance and implementing measures to reduce scope 3 emissions, including those from aircraft engine operations in the LTO cycle.

At the time of writing this technical paper (4 August 2023), more than 500 airports across 79 countries representing more than 49 per cent of global passenger traffic are Airport Carbon Accredited. Of these airports, 109 are accredited at the Neutrality level (3+) or at more demanding levels of the programme, including 4 Australian airports. In Australia, Brisbane and Newcastle airports are the highest accredited airports at the Transformation level (4). This reflects the commitments of both airports to absolute reduction of their GHG emissions in line with the Paris Agreement and through enhanced third-party engagement.

As detailed in Section 4.5 of this technical paper, WSA Co plans to join the ACI *Airport Carbon Accreditation* programme and prepare an Operational Sustainability Strategy and Operational Sustainability Plan to support aviation partners to reduce scope 3 emissions, including those produced by aircraft engine use in the LTO cycle (all phases of flight below 3,000 ft (914 m)).

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15 ACI EUROPE – *Airport Carbon Accreditation* Scheme (2009)

16 The Greenhouse Gas Protocol is a partnership between the World Resources Institute (WRI) and the World Business Council for Sustainable Development (WBCSD). It provides standards, guidance, tools, and training for business and government to measure and manage climate-warming emissions.

Figure 3.3 Six levels of *Airport Carbon Accreditation*

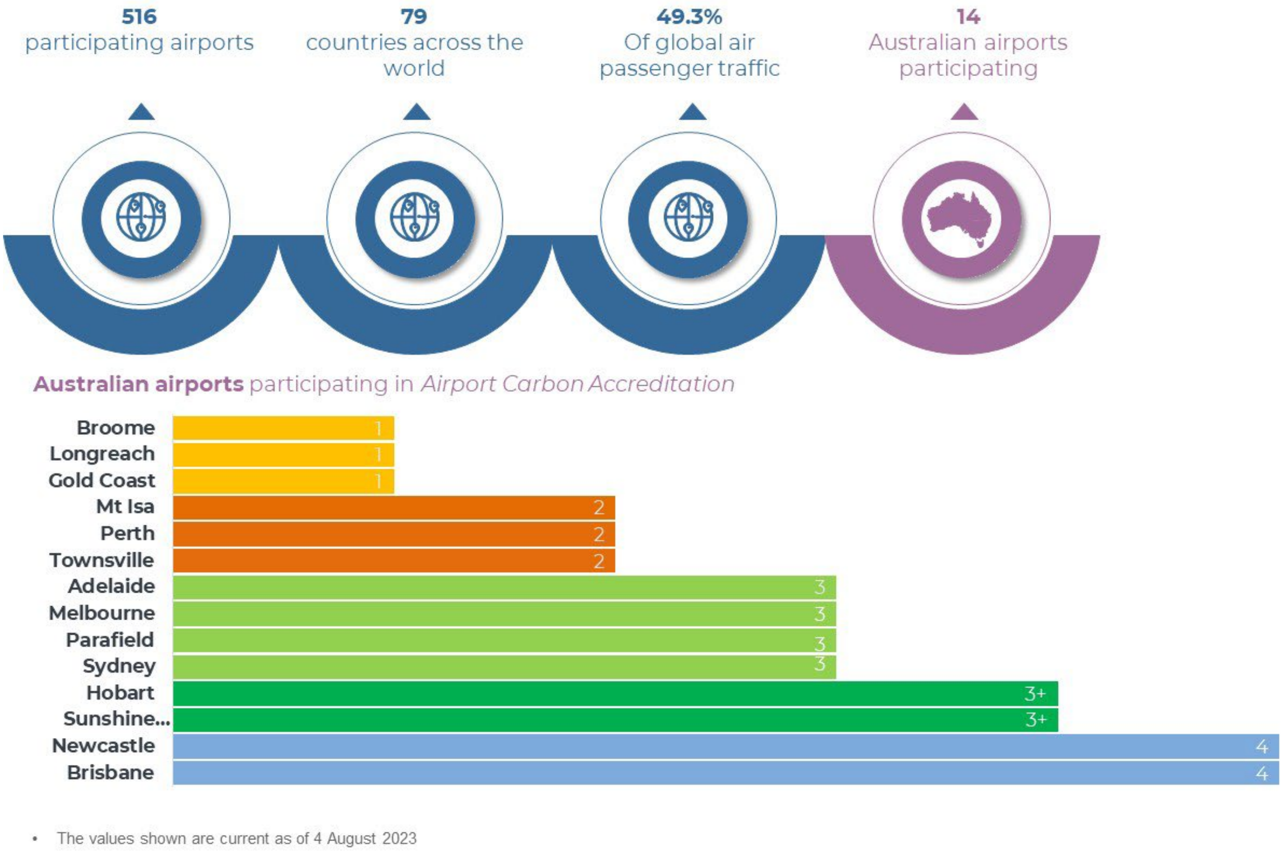

Figure 3.4 Australian airport participants in the ACI *Airport Carbon Accreditation* programme

3.4 Aircraft CO_2 Standard

In 2016, the ICAO, a UN agency, adopted the world's first CO_2 Standard for new aircraft types. This followed 6 years of analysis by 170 aviation experts from government, industry and environmental groups. The Aircraft CO_2 Standard[17] (ICAO 2017) is a significant milestone in the global air transport industry's long-term commitment to climate action. It forms part of a basket of measures to integrate more fuel efficient, low emission technologies into aircraft design and development, and complements other significant work already underway to improve operations, develop alternative SAFs and make better use of infrastructure.

The CO_2 Standard requires all newly developed aircraft and engines to incorporate the latest commercially available proven technologies for optimum fuel efficiency and reduction of GHG emissions. This means that aircraft CO_2 emissions form part of the certification process, alongside safety compliance, noise and other measures.

The Aircraft CO_2 Standard is based on an aircraft's performance during the cruise phase of flight when most fuel is consumed and most CO_2 is emitted. Performance is expressed in kilograms (kg) of fuel per flight km and averaged over 3 measurement points – at the beginning, in the middle and at the end of the cruise phase.

Aircraft covered by the CO_2 Standard from 2020 are:

- jet aircraft with a MTOW exceeding 5.7 tonnes
- jet aircraft over 60 tonnes subject to higher stringencies
- non-jet aircraft (propeller aircraft) with a MTOW exceeding 8.6 tonnes.

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17 ICAO, Annex 16 – Environmental Protection, Volume III, Aeroplane CO_2 Standard (latest edition)

The criteria above cover most aircraft types operating in the global fleet, including business, freight and passenger aircraft. Exemptions do apply in exceptional circumstances to the CO_2 Standard. For example, special-purpose aircraft designed for firefighting which are produced in low volumes. Otherwise, the CO_2 Standard applies to:

- all new aircraft types from 2020, with aircraft of less than 19 seats from 2023
- all existing aircraft currently in production from 2023
- all other in-production aircraft will have to comply by 2028.

According to the ICAO, each new generation of aircraft is approximately 15-20 per cent more efficient than the model it replaces. The CO_2 Standard mandates that these improvements continue with today's aircraft at least 70 per cent more efficient than the first jets in the 1960s. Figure 3.5 contrasts the CO_2 emissions performance of selected aircraft types that have flown the Sydney (Kingsford Smith) Airport to Singapore Changi Airport route (approximately 3,500 nautical miles (nm) or 6,480 km in flight distance) over the past 3 decades. The performance differences are significant and range up to 120 tonnes of CO_2 when comparing a new generation Boeing B787-9 (entered service in 2010) to a Boeing B747-400 (entered service in 1989).

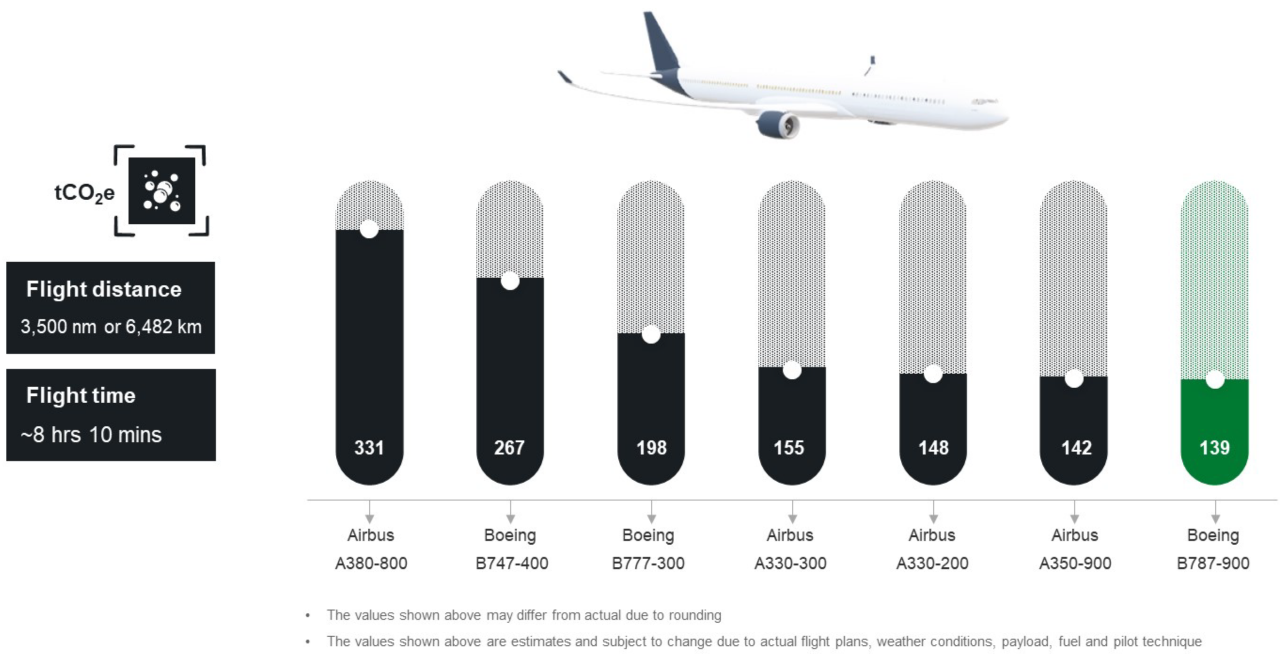

Figure 3.5 CO_2 emissions comparisons on SYD-SIN route (one-way) for selected aircraft types

The CO_2 Standard is to be regularly reviewed by the ICAO's Committee on Aviation Environmental Protection (CAEP). It complements the global market-based measure (MBM) developed by the ICAO to stabilise net CO_2 emissions from international aviation – the *Carbon Offsetting Scheme for International Aviation* (CORSIA) – which is not covered under the Paris Agreement. Refer to Section 4.2.1 of this technical paper for more details on CORSIA.

3.5 Long Term Carbon Goal for global airports

ACI in collaboration with member airports announced a sectoral Long-Term Carbon Goal (LTCG) in June 2021 following the conclusion of an in-depth global study on the decarbonisation potential of airports across the world.

The LTCG is: *"ACI member airports at a global level are committed to reach net zero emissions by 2050 for scope 1 and 2 emissions under the direct control of airport operators and urged governments to provide the necessary support in this endeavour."* [18]

Emissions from the operation of aircraft engines in the LTO cycle (below 3,000 ft or 914 m) and including inbound/outbound taxiing operations on the ground and use of onboard aircraft auxiliary power units (APUs) during turnarounds (when aircraft are parked at-gate) were excluded from the LTCG. For an airport operator, LTO cycle emissions would be classified as a scope 3 emissions source that is beyond its direct operational control.

Two Australian airports, Brisbane and Sydney (Kingsford Smith), supported the development of the LTCG, participating in working groups alongside other airports globally to develop the goal throughout 2020–2021.

In March 2021, the Swedish airport group Swedavia announced that all 10 of its airports – including the Stockholm-Arlanda hub which handled 26.8 million passengers and 232,895 flights in 2019 – had achieved net zero emissions across all operations under their control – A World First. According to ACI EUROPE more than 270 European airports operating across 30 countries are committed to net zero emissions with almost 130 of these airports run by 23 operators in pursuit of a target date of 2030 or earlier.

Airports in Australia committed to an accelerated net zero transition date of 2030 or earlier are shown in Figure 3.6. This transition to net zero is for scope 1 and 2 emissions and does not include scope 3 emissions from sources associated with aircraft engine use when taxiing, during landing or take-off or in Climb, Cruise and Descent (CCD) – the full flight.

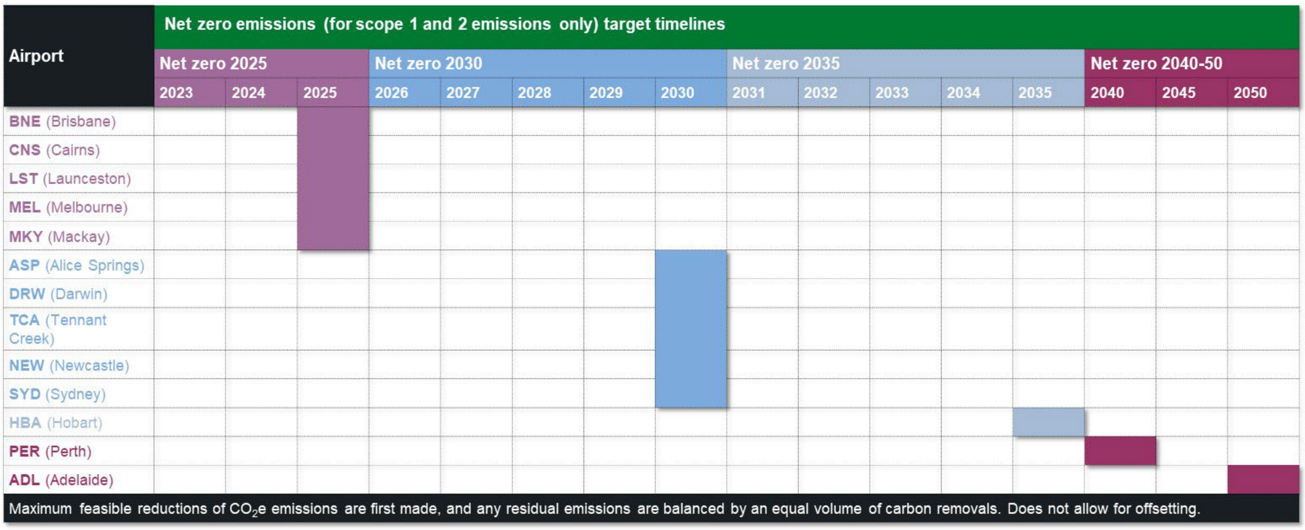

Figure 3.6 Australian airports in pursuit of net zero emissions by 2030 or earlier for scope 1 and 2 emissions only

[18] ACI, June 2021, Long Term Carbon Goal Study for Airports Report

3.6 Fly Net Zero by 2050

ACI joined forces with other key industry stakeholders led by IATA and approved on 5 October 2021 a resolution for the international air transport industry (airlines, airports, ANSP organisations, aircraft, and engine manufacturers) to achieve net zero emissions by 2050 – Fly Net Zero by 2050.

The net zero emissions commitment is in line with the recommendations of the scientific community and with the political consensus of the Paris Agreement stretch target to keep the global temperature rise to 1.5 degrees Celsius above pre-industrial levels (1850-1900).

The net zero emissions commitment is an absolute reduction target, meaning that by 2050 the net carbon emissions of the airline industry will be zero. The path to net zero emissions does not necessarily imply an immediate decrease in absolute carbon emissions. Projected growth of air transport in the next 10-years may exceed the effects of measures implemented by airlines, airports and other aviation organisations to decarbonise.

Almost 50 airlines worldwide have publicly pledged to reach net zero by 2050 with several like Alaskan Airlines working to an earlier target date of 2040.

In November 2019, the Qantas Group, which includes Jetstar and is part of the Oneworld Alliance, was the second airline in the world to publicly commit to net zero carbon emissions by 2050 and capping net emissions at 2019 levels. The Qantas Group airline has committed to reducing its carbon emissions by 25 per cent by 2030 (from 2019 levels) and transitioning to net zero emissions by 2050. Under the Qantas Group Climate Action Plan, released in March 2022 are the initiatives to achieve these goals.

The International Airlines Group made up of Aer Lingus, British Airways, Iberia, LEVEL and Vueling, was the first airline group worldwide to commit to net zero carbon emissions by 2050 and publish a roadmap to achieve this in October 2019.

In November 2021, Virgin Australia committed to net zero emissions by 2050. This commitment and pathway to achieve net zero emissions by 2050 is another step in Virgin Australia's sustainability journey, including being the first airline in Australia to test SAF in the supply chain. A basket of other innovative and practical measures complements Virgin Australia's ongoing sustainability efforts. This includes the decision to add more fuel-efficient Boeing MAX 10 aircraft to its fleet, commencing in 2023.

Other airlines expected to operate at WSI, including Air New Zealand, Cathay Pacific, Fiji Airways and Singapore Airlines all committed between May and November 2021 to achieve net zero carbon emissions by 2050. Investment roadmaps and implementation timetables are in place at these airlines to make net zero a reality. Freight operators including those that already operate in the Sydney Basin airspace, Atlas, DHL Global, FedEx and UPS all support the global aviation industry's commitment to achieve net zero emissions by 2050 and are developing measures to increase the use of SAF by as much as 30 per cent in the fuel mix by 2030 and 2035.

For all airlines, the development and use of SAF is central to the achievement of their goal of net zero emissions by 2050. Significant investment is also required in new generation aircraft, achieving higher operational efficiency, adopting low-carbon technology, and sourcing for high quality carbon offsets.

Figure 3.7 illustrates the core pillars to support the airlines' achievement of net zero emissions by 2050.

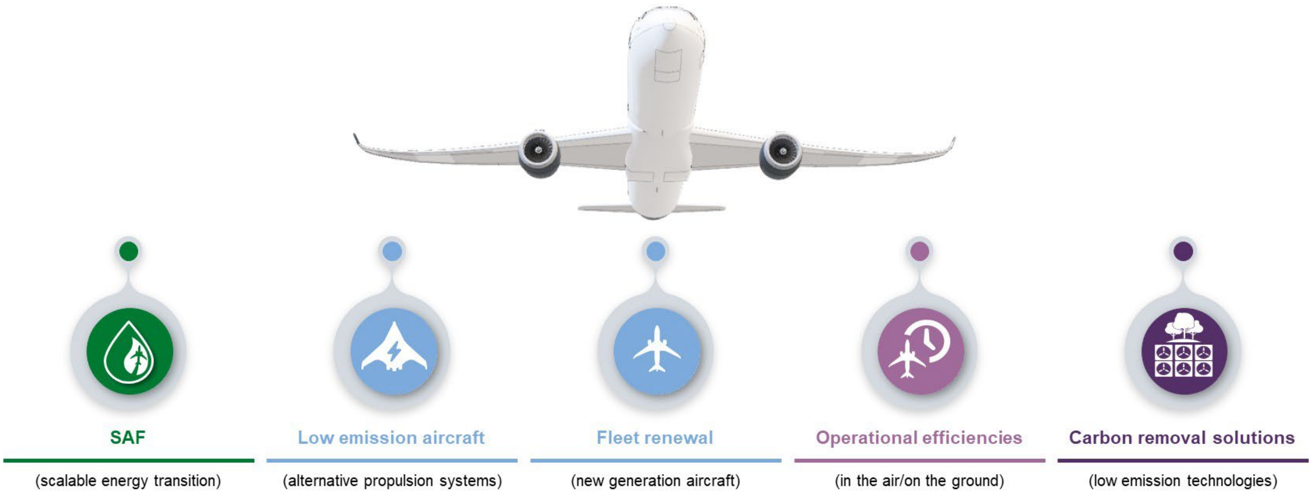

Figure 3.7 Airline net zero basket of measures

3.7 Waypoint 2050

Waypoint 2050 is a collaboration of global aviation experts coordinated by the cross-industry Air Transport Action Group (ATAG) looking at how to take decisive steps to accelerate climate action to reach net zero carbon emissions by 2050. The blueprint for global aviation's sustainable future is set out in Waypoint 2050 in line with the Paris Agreement's long-term climate goals which limits global warming to well below 2 degrees Celsius compared with pre-industrial levels (1850–-1900).

The Waypoint 2050[19] report explores how global aviation will be able to meet net zero by 2050, with the support of governments and the energy industry. It explored 3 main pathways to get there through:

- focus on prioritising technology and operations improvements
- prioritising investment in SAF over technology
- highly ambitious technology developments aimed at rolling out 200-seat hydrogen and electric powered aircraft before 2035.

In each of the 3 scenarios SAF plays a key role, driving between 50 per cent and 75 per cent of the decarbonisation. Carbon offsets and removal projects remain important for carbon neutral growth in the short term as technology improvements and SAF production increases but are not expected to play a central role in achieving 2050 goals. The 3 scenarios adapted from the Waypoint 2050 report are shown in Figure 3.8 and include:

- **Scenario 1:** pushing technology and operations
- **Scenario 2:** aggressive SAF development
- **Scenario 3:** aspirational and aggressive technology perspective.

[19] Air Transport Action Group, Second Edition September 2021, Waypoint 2050 – An Air Transport Action Group Project

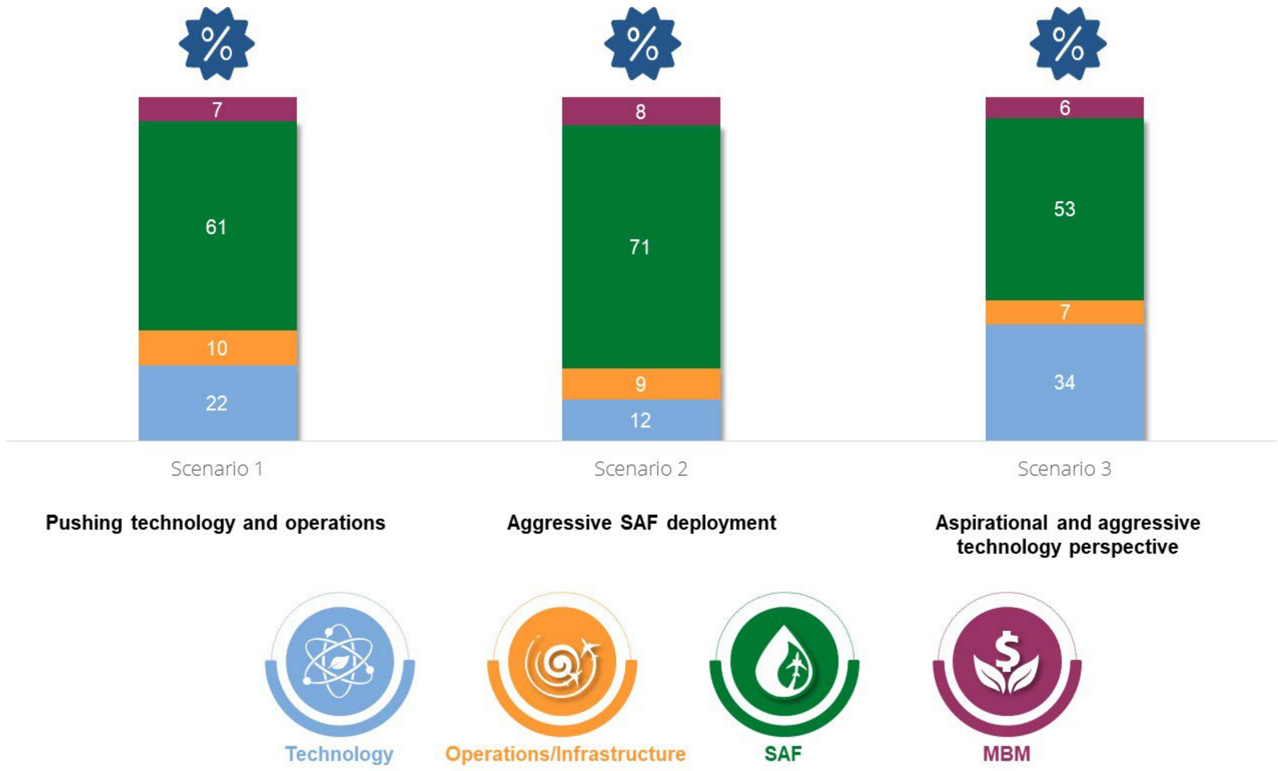

Figure 3.8 Global aviation net zero emission pathways by 2050

The level of decarbonisation under each scenario is underpinned by:

- **Traffic forecasts** – air traffic is projected to be around 8 per cent lower in 2050 compared to pre-COVID 2050 forecasts. There is expected to be around 10 billion passengers in 2050 and without any additional climate action (i.e., keeping today's fleet and operational efficiency) some 2 billion tonnes of CO_2e would be emitted in 2050.
- **Technology** – evolutionary technologies are emerging to drive more efficient aircraft and engines from novel configurations of blended and strut-braced wings and open rotor engines to electric and hydrogen powered propulsion systems. The expected timetable for new generation aircraft to enter global fleets remains uncertain although electric and hydrogen powered aircraft could be flying by 2030 and 2035 respectively.
- **Operations and infrastructure** – improvements in air traffic management, modernisation of airspace and shift to satellite-based navigations will all contribute to more direct, efficient and flexible flight operations.
- **SAF** – around 330–445 million tonnes of SAF are needed by 2050 for the global aviation industry to meet its net zero goal. This will require advanced feedstocks and power-to-liquid (PtL) alternatives to be available and significant increase in the number and geographical spread of processing facilities. According to the Sustainable Markets Initiative and CST, worldwide in 2022, 57 airports distributed around 150 million litres of SAF to more than 45 airlines. Since 2016, more than 450,000 flights have used SAF, including those operated by Qantas and Virgin Australia. Currently, SAF represents less than 0.1 per cent of global fuel consumption.
- **MBM** – offsetting will continue to play an important role in the interim to deal with residual CO_2e emissions, significant investment in carbon removal technologies will be required in the form of established nature-based solutions (i.e., biomass and soils, forestry, marine) and direct air capture (DAC) or carbon capture and storage (CCS) sometimes paired to the production of SAF.
- **1.5 degrees Celsius pathway alignment** – working together to reach the 1.5 degrees Celsius stretch goal based on latest published climate science.

3.8 Long Term Aspirational Goal for global aviation

The International Civil Aviation Organization (ICAO) is a specialised United Nations (UN) agency responsible for setting the global standards and recommended practices governing aviation. Assemblies are held triennially (every 3 years) for all the world's Member States. At the 2019 Assembly, ICAO agreed to consider the feasibility of options for a "long-term aspirational goal" (LTAG) for international civil aviation CO_2 emission reductions including new innovative aircraft technologies, SAF and more efficient infrastructure and operations.

In February 2022, the LTAG Report was approved at the CAEP/12 meeting. The LTAG Report is available on the ICAO website:

- https://www.icao.int/environmental-protection/LTAG/Pages/LTAGreport.aspx

It provides a technical assessment involving more than 280 experts over nearly 2 years on the feasibility of a LTAG for net zero emissions by 2050 and various roadmaps for implementation. The LTAG Report and the various Global Aviation Dialogues held by ICAO during and post-preparation, set the scene for the 41st Assembly (A41) in Montreal, Canada in September/October 2022.

On 7 October 2022 at the A41, the States of ICAO (including Australia) succeeded in agreeing to adopt the LTAG for global aviation to reach net zero emissions by 2050. This agreement represents a watershed moment that aligns the climate goals of the global aviation industry with the Paris Agreement and latest climate science. Global aviation now has the mandate for a common approach to decarbonise, building on the series of landmark commitments made in 2021 to achieve net zero emissions by 2050. Nonetheless, not all States will be able to move at the same pace with some developing States will need longer to reach net zero and the goal does not place obligations on all States.

These commitments support the scientific evidence presented by the IPCC in its October 2018 Special Report and August 2021 Sixth Assessment Report (AR6) to limit global warming to 1.5 degrees Celsius above pre-industrial levels. The AR6 report concluded that observed warming of the climate system is unequivocal, indisputably influenced by human activity and recognised at regional and local scales. The need to plan and deliver adaptation measures has never been more urgent, particularly when considering aviation carries 45 per cent of global trade and 58 per cent of global tourism. A growing number of governments around the world are also backing net zero aviation as part of a central plank of the industry's sustainable recovery and wider plans to transition to low carbon economies.

3.9 Strategic Net Zero Roadmaps for global aviation

In June 2023, the IATA unveiled a series of strategic roadmaps to set out the critical actions, dependencies and interim milestones to guide aviation's transition to achieve net zero carbon emissions by 2050.

Five roadmaps have been developed to address:

1. **Aircraft technology** – the development of more efficient aircraft and engines.
2. **Energy and New Fuels Infrastructure** – the development, availability and scalability of the fuels and new energy carrier infrastructure upstream from airports needed to facilitate the use of aircraft powered by SAF or hydrogen.
3. **Operations –** the opportunities for reducing emissions and improving energy efficiency by improving the way existing aircraft are operated.
4. **Policy –** the creation of globally aligned strategic policies to provide incentives and support for the aviation industry's transition to a net zero future.
5. **Finance –** the identification of finance mechanisms and products needed for aviation to achieve net zero by 2050 (i.e., technological advancements, infrastructure developments, and operational improvements).

Together, they show a clear direction and will evolve as we dig deeper to set interim milestones on the way to net zero. The roadmaps are aimed at airlines, but also for governments, suppliers, and financiers.

3.10 Original Equipment Manufacturers (OEM) net zero commitment

On 10 November 2021, a joint statement was made by the Chief Technology Officers of 7 of the world's leading aerospace OEMs reaffirming their commitment to a more sustainable aviation industry. This statement from Airbus, Boeing, Dassault Aviation, GE Aviation, Pratt and Whitney, Rolls-Royce and Safran updates a commitment made in June 2019 to support the goal of achieving net zero carbon emissions by 2050. Three primary areas of focus have been identified for the development of new low emissions technology for the global aviation industry:

1. **Airframes and engines** - advancing state-of-the-art airframe and engine design and technology.
2. **Fuel** - supporting increased availability and use of SAF and exploring the use of green hydrogen as a fuel of the future.
3. **New technologies** - continuing to develop technologies that will contribute to achieving net zero emissions through the collaboration of research institutions and aerospace suppliers, as well as by encouraging investment by airport operators in the infrastructure required to support these technologies.

The potential impacts of these improvements and why they are not included in the quantitative analysis used to inform this assessment are discussed later in this technical paper.

Chapter 4 Climate action commitments, legislation and policy requirements

This section outlines the relevant international, Australian and NSW statutory and policy requirements for aircraft GHG emissions relevant to this assessment.

WSI is located on Commonwealth land. The Airports Act (Cth) and EPBC Act (Cth) are the key pieces of legislation setting the regulatory framework for WSI and the assessment of aircraft GHG emissions for this EIS. Consideration has also been given to relevant NSW legislation including environmental planning instruments, policies and guidelines.

4.1 International GHG emission agreements and protocols

This section describes the overall international GHG emission agreements and protocols with aviation elements that are relevant to WSI. International agreements ratified by Australia that inform domestic climate and GHG emissions policy are noted as well as the global accounting protocol.

Section 4.2 addresses aviation specific GHG emissions agreements and schemes. International aviation-specific agreements flowing from Australia's council membership in the ICAO are also described, in addition to aviation-specific guidance and working groups.

4.1.1 COP 26 Glasgow, October-November 2021

The 26th Conference of the Parties of the UNFCCC on Climate Change ("COP26") was held in Glasgow in October/November 2021. On 10 November 2021, Transport Day, 23 countries (collectively responsible for more than 40 per cent of global aviation emissions) signed the International Aviation Climate Ambition Coalition (IACAC) declaration to decarbonise global aviation. This declaration committed the signatories to working together to accelerate action to reduce aviation CO_2 emissions in line with the aim to limit the global average temperature increase to 1.5 degrees Celsius.

Decisions made at COP26 were to support specific measures to reduce aviation emissions through a combination of greater uptake of SAF, strengthening the effectiveness of ICAO's global offsetting scheme for international aviation emissions, CORSIA, improving aviation infrastructure and operations, and continuing investment in the development of new aircraft propulsion systems.

4.1.2 Paris Agreement, December 2015

The COP of the UNFCCC issued the Paris Agreement in December 2015.

The main aim of the Paris Agreement is to '*strengthen the global response to the threat of climate change by keeping a global temperature rise this century below 2 degrees Celsius above pre-industrial levels and to pursue efforts to limit the temperature increase even further to 1.5 degrees Celsius'.*

The objective is to stabilise the concentration of atmospheric GHG emissions at a level that would *'prevent dangerous anthropogenic*[20] *interference with the climate system'* (Savaresi 2016).

On 11 August 2015, the Australian Government submitted its first Nationally Determined Contribution (NDC) to the UNFCCC to reduce emissions by 26 to 28 per cent below 2005 levels by 2030. Australia ratified the Paris Agreement under the UNFCCC and the Doha Amendment to the Kyoto Protocol, on 10 November 2016. This committed Australia to 5 yearly targets for emissions reduction and continues to shape Australia's policy on climate change to achieve the targeted reductions.

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[20] Scientists use the word "anthropogenic" in referring to environmental change caused or influenced by people, either directly or indirectly.

In June 2022, Australia updated its NDC under Article 4 of the Paris Agreement, committing to reduce GHG emissions to 43 per cent below 2005 levels by 2030. This updated 2030 target places Australia on the path to achieve net zero emissions by 2050. These targets are legislated under the Australian Government's new *Climate Change Act 2022* (CC Act) (Cth).

Under the UNFCCC, domestic and international aviation are treated separately. Domestic aviation emissions are counted as part of a national set of targets while international aviation emissions are dealt with as part of Australia's participation in ICAO under CORSIA, the MBM adopted by ICAO in 2016 to keep carbon emissions at 2020 levels.

4.1.3 The GHG Protocol

The international GHG Protocol[21] is a collaboration between the World Resources Institute (WRI) and the World Business Council for Sustainable Development (WBCSD). Globally accepted, it provides guidance on the calculation and reporting of carbon footprints and is the basis for determining aircraft main engine GHG emissions associated with the use of airspace for single runway operations (05/23) at WSI.

In the GHG Protocol (2004), emissions are categorised into 3 scopes, and each should be reported separately. These scopes provide a means for identifying the ownership and control of emissions sources and thus responsibility for managing the emissions. The scopes are described in Table 4.1.

Table 4.1 GHG emission scope and sources

Scope	Description
1	Direct GHG emissions that occur from sources owned and/or controlled by the reporting company (i.e., airline or ALC), such as emissions from the combustion of fuels in owned/controlled generators including back-up (emergency) systems, fire extinguishers and fleet vehicles and for airlines and freight companies, the aircraft they operate both in the air and on the ground.
2	Indirect emissions from the offsite generation of purchased electricity consumed by the reporting company (i.e., airline or ALC).
3	All other indirect emissions, which are the consequence of the reporting company's (i.e., airline or ALC) activities, but occur from sources not owned and/or controlled by the reporting company, including ground transport, third party energy use, third party fleet vehicles, staff commute and business travel, offsite waste/water treatment, onboard aircraft APU use during turnarounds when parked at the gate or on a remote stand, and aircraft main engine use on the ground (aircraft ground running, taxiing) and in the air (take-off roll, initial climb, final approach and landing roll) in the LTO cycle, etc.

Figure 4.1 illustrates the GHG Protocol's scopes and emission source categories for a reporting company. In the case of WSI, the scope boundaries for GHG emissions from aircraft main engine operations in the LTO cycle or in full flight will differ for an ALC and an airline. This source of emissions would be classified as scope 3 for an ALC (indirect emissions from airport-related activities) and scope 1 (direct emissions from aircraft operations) for an airline or a freight operator.

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[21] World Resources Institute and World Business Council for Sustainable Development "GHG Protocol, A Corporate Accounting and Reporting Standard" (WRI, 2004)

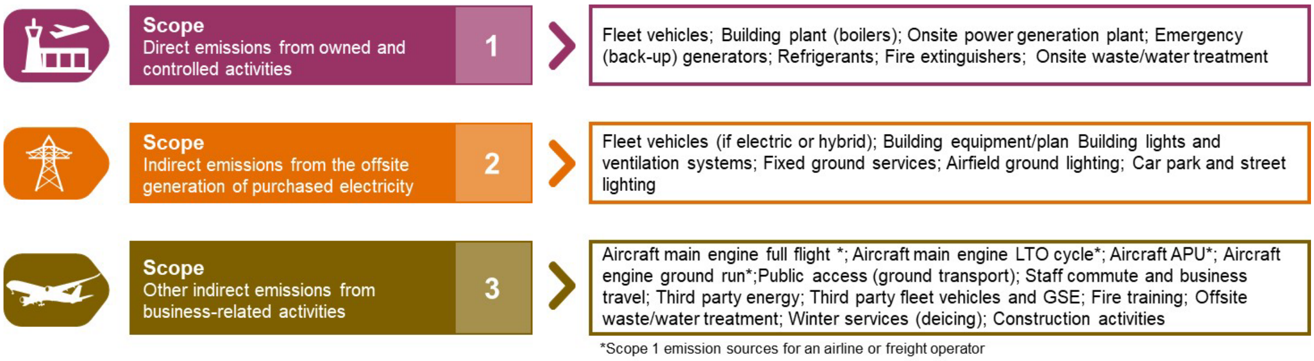


Figure 4.1 Aviation scope and emission source categories

4.1.4 World Economic Forum Clean Skies for Tomorrow

Established in 2019, the World Economic Forum's (WEF) Clean Skies for Tomorrow (CST) initiative, is a coalition across the global aviation industry's value chain working to facilitate the transition to net zero flight by 2050. The CST coalition is a public-private partnership driven to shift to zero emissions aviation through SAF and other clean propulsion technologies.

SAF is an essential piece of the puzzle in global aviation's decarbonisation pathway, especially with next generation technologies like electric and hydrogen-powered propulsion still years away from application at scale. The current impasse to SAF is the cost burden associated with securing feedstock (bio or synthetic) in reliable amounts, having the plant available to process and supply the SAF at a commercially attractive and scalable level that reaches relative cost parity with existing fossil fuel-derived options.

Led by the WEF in collaboration with the Rocky Mountains Institute and the Energy Transitions Commission, the CST coalition aims to break this impasse and advance the commercial scale of viable production of sustainable low-carbon aviation fuels (bio and synthetic) for broad adoption in the industry by 2030. Already many airlines and airports worldwide have publicly declared support to accelerate the supply and use of SAF to reach a minimum 10 per cent in the overall fuel mix by 2030 as part of a meaningful and proactive step towards the achievement of their individual net zero emission ambitions.

Sydney (Kingsford Smith) Airport was one of 60 original signatories in Geneva on 21 September 2021 along with airlines, other airports, fuel suppliers and aviation support companies.

The founding champions of the CST coalition include the Airbus Group, Heathrow Airport Limited, KLM Royal Dutch Airlines, Royal Schiphol Group, Shell, SkyNRG, SpiceJet and The Boeing Company.

4.2 International aviation GHG emission agreements and schemes

4.2.1 ICAO market-based measure, 2016

As mentioned above, in 2016, the ICAO adopted Assembly Resolution A40-19, a MBM to stabilise GHG emissions from international aviation activities at 2020 levels (revised to 2019 levels because of the COVID-19 pandemic).

Known as the *Carbon Offsetting Scheme for International Aviation* (CORSIA)[22], it supports efforts to stabilise the mid-term growth in aviation emissions while allowing long-term SAF and technology solutions time to mature and enter the global fleet.

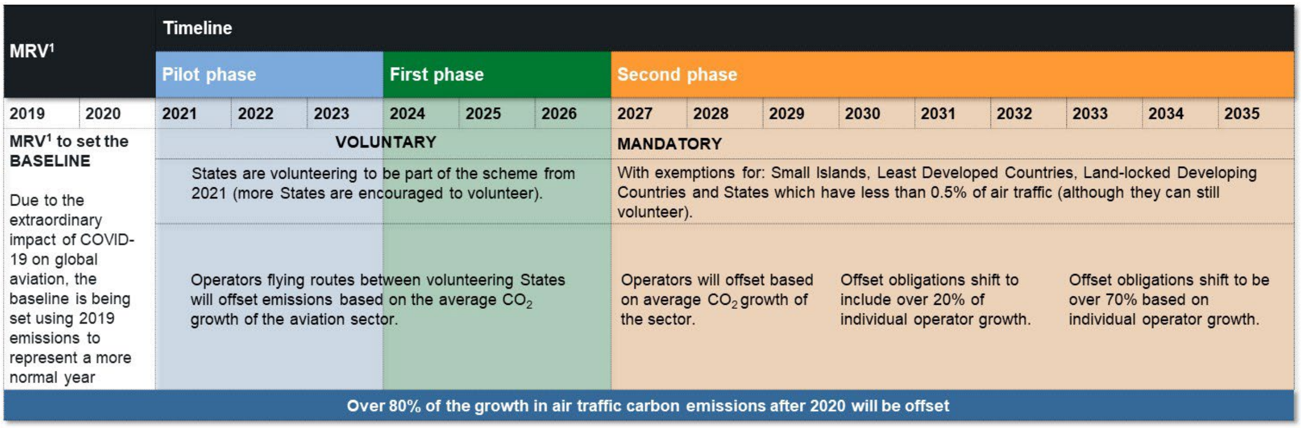
CORSIA does not cover domestic aviation, as this is subject to action under NDCs outlined in the Paris Agreement.

Under CORSIA:

- all operators must monitor, report and verify (MRV) their emissions on all international flights (from 1 January 2019 to 31 December 2020) to set the baseline with 2019 emissions being used to represent a more normal year of emissions following the unanticipated shutdown of air transport due to the COVID-19 pandemic
- operators will be required to purchase 'emission units' to offset growth in carbon emissions from those routes covered by the scheme.

After extensive negotiations amongst the States, agreement was reached that CORSIA's baseline will be set at 85 per cent of 2019 levels from 2024.

CORSIA is to be implemented in 3 phases as shown in Figure 4.2.



MRV
Note (1) Monitoring, reporting and verification

Source: Adapted from ICAO

Figure 4.2 ICAO CORSIA, the world's first global, sectoral market mechanism

From 2021 to 2026, only flights between volunteering states will be subject to offsetting requirements. From 2027 to 2035, all flights will be offset, except for flights to/from Least Developed Countries, Small Island Developing States, Landlocked Developing Countries and small aviation markets with less than 0.5 per cent of air traffic, unless they voluntarily decide to participate.

According to ICAO, there are 115 participating States (countries) including Australia who have volunteered for the pilot phase of CORSIA. This covers 77 per cent of international aviation activity (refer to Figure 4.3).

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[22] ICAO Annex 16 – Environmental Protection, Volume IV, Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA)

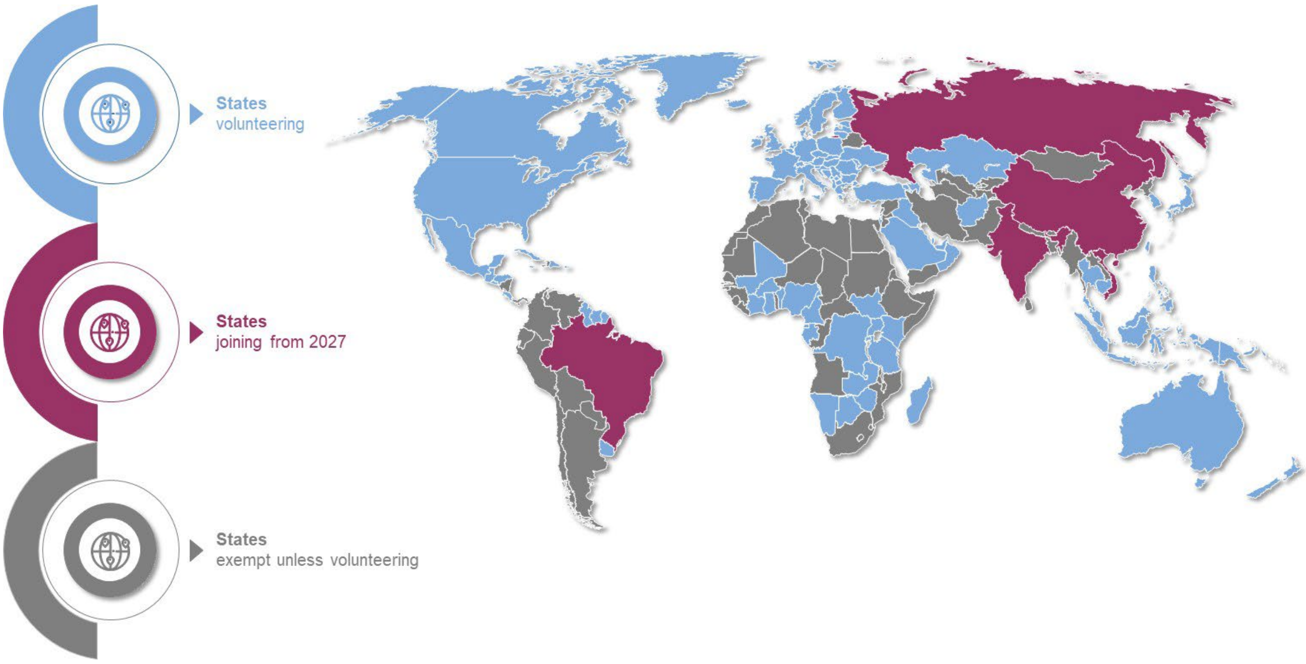

Figure 4.3 ICAO CORSIA, Member States that have volunteered to participate

4.2.2 ACI Guidance Manual: Airport GHG Emissions Management

The ACI *Guidance Manual: Airport Greenhouse Gas Emissions Management* (ACI 2009), which is currently under review, presents a method for defining, quantifying, regulating, reducing, offsetting, reviewing and reporting GHG emissions associated with airport activities and aviation operations. This guidance is relevant because it defines who has primary responsibility for GHG emissions management in the aviation sector.

4.3 Australia

On 16 June 2022, the Australian Government submitted an updated NDC under Article 4 of the Paris Agreement to the UNFCCC. The updated NDC, commits Australia to reduce GHG emissions 43 per cent below 2005 levels by 2030. Australia also reaffirmed its target to achieve net zero emissions by 2050.

These targets are economy-wide emissions reduction commitments, covering all sectors and GHGs included in Australia's national inventory. The revised 2030 commitment is both a single-year target to reduce emissions 43 per cent below 2005 levels by 2030 and a multiyear emissions budget from 2021–2030. In September 2022, the Government passed the CC Act (Cth), enshrining these targets in legislation (refer to Section 4.3.3).

Under the UNFCCC, domestic and international aviation are treated separately. Domestic aviation emissions are counted as part of country targets while international aviation emissions are dealt with separately as part of Australia's participation in ICAO.

Domestic aviation emissions are monitored through the National Greenhouse and Energy Reporting (NGER) scheme and are addressed by the DCCEEW and the Clean Energy Regulator (CER) through several mechanisms including:

- the **Emissions Reduction Fund** (ERF), a voluntary scheme that aims to provide incentives for a range of organisations and individuals including airline and airport operating companies to adopt new practices and technologies to reduce their emissions. The aviation method sets the rules for aircraft used on domestic routes to improve fuel efficiency, switch to cleaner (more sustainable) energy sources and implement low emission operational practices during all phases of flight

- the **Safeguard Mechanism**, a framework for Australia's largest emitters to measure, report and manage their emissions. Large facilities including airline companies, whose net emissions exceed the safeguard threshold (i.e., more than 100,000 tonnes of CO_2e emitted from scope 1 sources) are encouraged, to keep their emissions at or below baseline levels.

4.3.1 Environment Protection and Biodiversity Conservation Act 1999

The EPBC Act (Cth) provides the framework for protecting and managing nationally (and internationally) important flora and fauna, ecological communities and heritage places (including World heritage). Under the EPBC Act (Cth) these are defined as MNES. The EPBC Act (Cth) is Australia's main legislative instrument for implementing its obligations under the World Heritage Convention. The EPBC Act (Cth) also confers jurisdiction over actions that have the potential to make a significant impact on the environment where the actions affect Commonwealth land or are undertaken on behalf of Australian Government agencies.

Under Section 160 (2)(b) of the EPBC Act (Cth), an Australian Government agency (or employee) must obtain and consider advice from the Minister for Environment before a PAAM is adopted or implemented where the aircraft operations will have or is likely to have a significant impact on the environment. The preliminary airspace design for the project is a PAAM within the meaning of the EPBC Act (Cth).

A referral was made under Section 161 of the EPBC Act (Cth) by the DITRDCA, Airservices Australia and CASA in 2021 (EPBC 2022/9143). The delegate for the Minister for Environment determined on 28 January 2022 that the project would be assessed by way of an EIS and in doing so issued the EIS Guidelines. The DITRDCA is the nominated proponent for the project.

In accordance with the EPBC Act (Cth) and EIS Guidelines (EPBC 2022/9143), the EIS requires an assessment of impacts on GHG emissions to provide an understanding of the nature, extent and significance of potential impacts on the environment associated with the project. The EPBC Act (Cth) is the Australian Government's central piece of environmental legislation, which commenced on 16 July 2000.

The *'Loss of climatic habitat caused by anthropogenic emissions of greenhouse gases'* is listed as a Key Threatening Process (KTP) under the EPBC Act (Cth).

4.3.2 Matters of National Environmental Significance (MNES)

The EPBC Act (Cth) lists 9 MNES.

The MNES most relevant to the potential impact of GHG emissions from aircraft engine use are:

- world heritage properties (the Greater Blue Mountains Area (GBMA) World Heritage property)
- national heritage places
- wetlands of international importance (often called 'Ramsar'[23] wetlands after the international treaty under which such wetlands are listed)
- nationally threatened species and ecological communities
- migratory species.

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[23] The *"Ramsar Convention on Wetlands of International Importance Especially as Waterfowl Habitat"*, also known as the *"Convention on Wetlands"*. It is named after the city of Ramsar in Iran, where the international convention was signed in 1971.

4.3.3 National Greenhouse and Energy Reporting Act 2007

The *National Greenhouse and Energy Reporting Act 2007* (NGER Act) (Cth) provides for the reporting and dissemination of information related to GHG emissions, GHG projects, energy production and energy consumption. Under the NGER Act (Cth), corporations in Australia which exceed thresholds for GHG emissions or energy production, or consumption are required to measure and report data to the CER on an annual basis (the NGER Scheme).

The *National Greenhouse and Energy Reporting (Measurement) Determination 2008* identifies several methodologies to account for GHGs from specific sources which are relevant to WSI. This includes emissions of GHGs from direct fuel combustion (e.g., fuel for transport energy purposes).

Aircraft GHG emissions associated with single runway operations at WSI would be included in reporting under the NGER Scheme.

The DCCEEW is responsible for the GHG emissions inventories and reporting by economic sector and by each Australian state and territory. Australia's National Greenhouse Accounts contain GHG emissions inventories on Australia's historic GHG emissions dating back to 1990. This data is used to measure progress towards Australia's emissions reduction target and to meet reporting requirements under the Paris Agreement, UNFCCC and the Kyoto Protocol.

The DCCEEW submits a NIR to the UNFCCC each year. Annual GHG emissions inventories are also prepared for the GHG emissions of each Australian state and territory. These inventories disaggregate the GHG emissions the emissions estimates from the NIR.

Projections of Australia's future GHG emissions to 2035 are also available to track progress towards Australia's emissions reduction targets and its 2050 net zero emissions trajectory.

4.3.4 Climate Change Act 2022

On 8 September 2022, the Australian Government's CC Act (Cth) was passed in the Australian Parliament. The CC Act (Cth) legislates Australia's targets to reduce GHG emissions by 43 per cent below 2005 levels by 2030 and achieve net zero emissions by 2050.

On 13 September 2022, the accompanying *Climate Change (Consequential Amendments) Act 2022* (Cth), also took effect to further support Australia's approach on climate change action and to focus Australian Government organisations on achieving the emissions reduction targets in line with the national net zero emissions trajectory by 2050.

The legislation provides a collaborative platform for emissions reduction while ensuring reliable energy supplies and strengthening accountability through an annual statement by the Minister for Climate Change and Energy to the Australian Parliament. An independent Climate Change Authority is tasked to advise on Australia's progress towards these targets, and on what Australia's future targets should be.

The CC Act (Cth) requires the Minister for Climate Change and Energy to prepare and publish an Annual Climate Change Statement (DCCEEW 2022). This holds the Australian Government accountable for meeting Australia's emissions reduction targets and to create effective climate change policy. The Annual Climate Change Statement provides a transparent account of the Australian Government's actions and policy, highlighting progress towards emissions reduction targets and the risks posed by a changing climate to the national economy.

The first Annual Climate Change Statement 2022 was published by the DCCEEW.

4.3.5 Australia's Long-Term Emissions Reduction Plan (LTERP)

On 26 October 2021, the Long-Term Emissions Reduction Plan (LTERP) was released. The LTERP sets out the practical steps to be taken over the next 3 decades to reduce Australia's emissions to net zero by 2050. The Technology Investment Roadmap in the LTERP prioritises the technologies required to cut emissions while creating jobs and growing the Australian economy.

The LTERP is anchored by 4 pillars:

1. Driving down the costs of low emissions technologies.
2. Deploying these technologies at scale.
3. Seizing opportunities in new and traditional markets.
4. Working with other countries on the technologies needed to decarbonise the world's economy.

4.3.6 State Action Plan, Managing the Carbon Footprint of Australian Aviation, 2022

Australia is an active participant and supporter of the ICAO's work to develop a multilateral and comprehensive approach to the management of CO_2e emissions from international civil aviation. ICAO Member States like Australia prepare a voluntary action plan to communicate information on their actions to address CO_2e emissions from international civil aviation to ICAO. This information is presented in State Action Plans (SAPs) to report to ICAO on all relevant activities and initiatives being undertaken by States to demonstrate their progress toward reducing CO_2e emissions by international civil aviation and meeting the goals set by ICAO for the global aviation industry.

Australia also supported the landmark agreement reached at the 39th ICAO Assembly held in September/October 2016 in Montreal, Canada, to adopt a new global MBM, ICAO's CORSIA.

Australia published its first SAP, Managing the Carbon Footprint of Australian Aviation, in November 2012 in response to the 2010 ICAO Assembly Resolution A37-19.

The 2017 SAP (DIRD 2017) built on the work of the 2012 SAP by outlining Australia's progress in contributing to the ICAO's global aspiration goal of achieving carbon neutral growth from 2020 onwards. It reported that CO_2e emissions from commercial aviation activities in Australia were around 22 Mt CO_2e in 2016. The Australian Government Department of the Environment and Energy (at 2017) projected that CO_2e emissions from domestic aviation would rise steadily at an average of 2.2 per cent per annum out to 2034-35.

Aviation activity in Australia includes domestic and international aviation. For the purposes of the SAP, Australia uses the IPCC's criteria for defining domestic and international aviation (which differs from the ICAO definition):

- domestic aviation refers to flights beginning and ending within Australia
- international aviation refers to flights whose 'First Port of Call' is from Australia or whose 'Last Port of Call' is to Australia, regardless of airline nationality and registration marks.

In October 2022, the DITRDCA released the 2022 SAP to highlight Australia's continued progress toward reducing emissions of CO_2e emissions from aviation and notable achievements to date. Since 2017, activity in Australia's international aviation sector decreased significantly due to the impacts of COVID-19 on air travel demand. Border restrictions on international passenger movement saw scheduled international passenger numbers decrease significantly. The reduction in international air services has had various effects, including reducing fuel efficiency as load factors reduced.

4.3.7 Airservices Australia National Operating Standard (NOS) Environmental Management of Changes to Aircraft Operations (July 2022)

The Environmental Management of Changes to Aircraft Operations National Operating Standard (AA-NOS-ENV2.100 Version 18 Effective 01 July 2022) is an internal Airservices Australia Standard. The Standard is used by Airservices Australia to prescribe the requirements for environmental impact assessment, social impact analysis and community engagement that must be met, prior to implementing changes to aircraft operations.

The Standard applies to all changes proposed to air traffic management practices (proposals) that may facilitate a change to existing aircraft operations.

Proposals include, but are not limited to, the following:

- new, or amendment to an existing, instrument flight procedure
- new, or amendment to an existing, air route
- re-classification of airspace
- change to noise abatement procedures or preferred runways
- a change that allows use of a flight path/airspace by different type or quantity of aircraft.

While recognising that safety is always the most important consideration, one of the primary objectives of environmental change management under the Standard relevant to fuel and emissions is, to *“assist in achieving efficiency outcomes for our customers, through improved flight paths and associated reductions in fuel costs and emissions.”*

Environmental Change Screening is to be applied to any airspace change proposal to aircraft operations to determine the appropriate level of environmental assessment to be undertaken.

The changes proposed to aircraft operations in the Sydney Basin airspace from WSI result from the introduction of new flight paths, airspace containment and operational procedures. These changes will be permanent to facilitate aircraft operations along these flight paths to arrive at or depart from WSI. Within 45 nm (83 km) of WSI and beyond, aircraft using these flight paths could be audible and/or visible, as they are expected to operate up to approximately 20,000 ft (6 km) and higher depending on the flight path in use, type of aircraft, origin-destination, weather, pilot technique, and other factors.

Along sections of these flight paths, especially near WSI aircraft may overfly populated residential areas and other sensitive areas.

Appendix B of the Standard establishes the fuel burn and emissions criteria to meet obligations under the EPBC Act (Cth). These criteria are shown in Table 4.2.

Table 4.2 Fuel burn and emissions criteria in the Standard for seeking advice under the EPBC Act (Cth)

Assessment element	Criteria	Section in this technical paper
Airport and flight characteristics		
Airport size and category	A large airport that has both a staffed Air Traffic Control tower and runways equal to or wider than Category 4C	WSI is a new 24/7 airport capable of handling domestic and international passenger services, and freight services
Aircraft movements	≥ 100 RPT movements per day ≥ 200 movements per day at a training airport	Chapter 6 of this technical paper provides information on the aircraft fleet mix and daily movement numbers projected in 2033 and in 2055
Change in distance flown	≥ 20 per cent increase in flight path (within a 20 nm (37 km) radius from the ARP)	WSI is a new 24/7 airport

Assessment element	Criteria	Section in this technical paper
Fuel burn and emissions characteristics		
Increase in fuel burn, CO_2 and other CO_2-e emissions below 10,000 ft (compared to the existing situation) using AEDT	≥ 20 per cent	Chapter 8 of this technical paper provides an assessment of aircraft tailpipe CO_2e emissions generated below 10,000 ft (3,048 m) from engine exhausts by aircraft using the flight paths developed for WSI's preliminary airspace design
Increase in fuel burn, NOx, SOx and Particulate Matter below 3,000 ft (compared to the existing situation) using AEDT	≥ 20 per cent	Not covered in this technical paper (refer to Technical paper 2)

4.4 New South Wales

4.4.1 Net Zero Plan Stage 1: 2020-2030

In response to Australia's national plan and various global commitments, the NSW Government has committed to action on climate change and a goal for a net zero carbon economy by 2050. This is set out under the Net Zero Plan Stage 1: 2020-2030. The Plan published in March 2020 outlines the NSW Government's blueprint to protect the future by growing the economy, creating jobs and reducing emissions over this decade to 2030.

The Plan aims to strengthen the prosperity and quality of life of the people of NSW, while helping to achieve the State's objective to deliver a 50 per cent cut in emissions by 2030 compared to 2005 levels. It also supports a range of initiatives targeting energy, electric vehicles, hydrogen, primary industries, technology, built environment, carbon financing and organic waste. The Plan is structured in 4 parts:

1. A global challenge with local opportunities – the trends and opportunities arising from global climate change action.
2. Progress and projections – current progress within NSW to reduce GHG emissions and future projections.
3. The net zero priorities – the NSW Government's net zero priorities.
4. Keeping track – the NSW Government's approach to tracking progress.

4.4.2 State of the Environment Reporting

The NSW Environment Protection Authority (EPA) prepares a State of the Environment (SOE) report every 3 years. The SOE report snapshots the status of the main environmental issues facing NSW bringing together data and information from across all state government agencies with responsibility for managing NSW's environmental assets. It is anchored by 6 environmental themes:

1. Drivers
2. Human Settlement
3. Climate and Air
4. Land
5. Biodiversity
6. Water and Marine.

Each environmental theme is divided into specific topics with status indicators and further information. GHG emissions from transport, inclusive of domestic (intrastate within NSW) aviation sits within the Human Settlement theme. With current stated policies implemented, NSW's emissions of CO_2e by 2030 are projected to be 47–52 per cent lower than 2005 levels.

4.5 WSI sustainability commitments

WSA Co published a Design and Construction Sustainability Plan in 2022 (WSA Co 2022).

The Plan sets out the priorities and approach to design and build WSI as a sustainable airport. Embedded in the Plan is how WSA Co intends to manage and measure sustainability, demonstrate leadership, work continuously to achieve outcomes and targets beyond minimum requirements and fulfil applicable compliance obligations from the Airport Plan and 2016 EIS.

An Operational Sustainability Strategy and Operational Sustainability Plan are currently in development and will be made available by WSA before the airport operations begin in late-2026. A core building block will be a roadmap to progress WSI along a Carbon Neutral Pathway. This will be supported by participation in the ACI's *Airport Carbon Accreditation* Programme and a strategy to support aviation partners to reduce scope 3 emissions, including those produced by aircraft engine use below 3,000 ft (914 m) in the LTO cycle.

Reducing the operational carbon footprint of WSI especially from aircraft engine use in the LTO cycle is a significant challenge and requires action by several aviation partners. WSA Co, in step with other leading ALCs in Australia and worldwide, must lead by example and invest to put in place the enabling interventions, supported by the right policies, standards, and incentives, that allow airlines, freight companies, other aviation partners and passengers to cut their emissions too.

WSA is planning to enter ACI's *Airport Carbon Accreditation* programme at either of the 2 current highest available levels:

- Transformation level (4)
- Transition level (4+).

This means that WSA Co is required to set a policy commitment to absolute emissions reductions of CO_2e and implement a Carbon Management Plan (defining the emissions reduction trajectory, interim milestones and measures to achieve a future target) as it works towards an absolute long term science-based emissions reduction target in line with the IPCC's 1.5 degrees Celsius pathway. It will also help WSI operate with the lowest carbon footprint possible as WSA Co works closely with all its stakeholders to address third party emissions of CO_2e, particularly those sources of emissions that are outside its direct control and ownership (i.e., aircraft flight operations).

Depending on which level of accreditation WSA Co decides to pursue, high quality, independently verifiable carbon credits could be purchased to offset or remove unavoidable, hard to abate residual emissions.

Chapter 5 Description of significance criteria

To ensure a consistent approach across each impact assessment presented in this EIS, the framework used throughout the technical paper for the significant impact assessment is the one detailed in Chapter 10 (Approach to impact assessment) of the EIS.

Specific criteria have also been developed for the assessment of GHG emissions from engine exhausts by aircraft using WSI's flight paths as described in Table 5.1.

Table 5.1 Aircraft GHG emissions significance criteria

Impact severity	Description	Other comments
Major	A significant increase in annual GHG emissions representing >1% of Australia's total annual GHG emissions, or >1% of NSW's total annual GHG emissions, excluding the Land Use, Land-Use Change and Forestry (LULUCP) sector[24]	Comparison with latest publicly available GHG emissions inventories. Exceedance of these levels assumes negative reputation and media attention globally, affecting the Australian Government's ability to comply with the Paris Agreement.
High	An increase in annual GHG emissions representing >0.5% but <1% of Australia's total annual GHG emissions, or >0.5% but <1% of NSW's total annual GHG emissions, excluding LULUCP	Comparison with latest publicly available GHG emissions inventories. Exceedance of these levels assumes negative reputation and media attention nationally, affecting the Australian Government's ability to comply with the Paris Agreement.
Moderate	An increase in annual GHG emissions representing >0.1% but <0.5% of Australia's total annual GHG emissions, or >0.1% but <0.5% of NSW's total annual GHG emissions, excluding LULUCP	Comparison with latest publicly available GHG emissions inventories. Exceedance of these levels assumes negative reputation and media attention state-wide, affecting the NSW Government's delivery of a net zero economy by 2050.
Minor	An increase in annual GHG emissions representing <0.1% of Australia's total annual GHG emissions, or <0.1% of NSW's total annual GHG emissions, excluding LULUCP	Comparison with latest publicly available GHG emissions inventories. Exceedance of these levels assumes negative reputation and media attention state-wide and locally, affecting local efforts to deliver a net zero economy by 2050 for Western Sydney.
Negligible	No net annual increase in Australian aviation's share of total annual GHG emissions, or NSW's aviation share of total GHG emissions when measured against 2019 levels (carbon neutral growth)	

The contribution of aircraft GHG emissions to climate change is a global issue, not just a national, state, or local one. The severity assessment of GHG emissions resulting from aircraft arriving and departing WSI is therefore assessed in this context. Reporting thresholds have been used to differentiate between the severities of the impacts because they usefully illustrate the importance of emissions levels on a local to global scale.

[24] Accounts for emissions from and removals by human-induced activities in forest lands, croplands, grasslands, wetlands and settlements, including land clearing, timber harvesting, wildfires and prescribed fires (NSW Department of Planning and Environment).

Chapter 6 Methodology

6.1 Overview

This section covers the methodology developed to estimate the CO_2 and CO_2e emissions generated by aircraft engines using the new flights paths introduced at WSI in 2033 and in 2055. It briefly gives an overview of the previous assessment from the 2016 EIS, the current assessment study boundary and metrics used.

Version 3e of the Aviation Environmental Design Tool (AEDT), a software system produced by the United States (US) Federal Aviation Administration (FAA), was used to model and estimate aircraft fuel consumption and associated CO_2e emissions from the use of flight paths and the route network connecting to single runway operations at WSI.

Aircraft tailpipe CO_2e emissions associated with aircraft engine use along the newly introduced flight paths for WSI are explained in this section. They include CO_2 and CO_2e emissions from the operation of aircraft engines in the LTO cycle (exclusive of aircraft taxiing on the ground), an extended C-D cycle below 10,000 ft (3,048 m) and full flight emissions for all flights departing from WSI to destination airports across its anticipated route network.

Rising concentrations of atmospheric CO_2 emissions contribute to climate change. Aircraft using WSI's flight paths will be a source of CO_2e emissions when arriving and departing from Runway 05 or Runway 23. An inventory has been developed to account for the CO_2 emissions from the 10 most common aircraft types anticipated to operate at WSI in 2033 and in 2055. These were aggregated with CO_2 and reported as a single number of 'carbon dioxide equivalents' (CO_2e), as appropriate.

The aircraft types are obviously for those currently in service with airlines in Australia and overseas. Hence the assessment is conservative in not speculating on future anticipated and necessary improvements in engine technology or alternative population systems being introduced into airline flights in 2033 and 2055 and resulting in lower emissions.

The purpose of this assessment was to calculate aircraft tailpipe CO_2e emissions from aircraft engine exhaust operating along WSI's flight paths and route network in 2033 (represents the early years of WSI operations) and in 2055 (represents the year when single runway operations are expected to be operating at near capacity). Excluded from this assessment are CO_2e emissions associated with all flights departing from origin airports to WSI, aircraft engine use on the Airport Site (i.e., ground-based taxiing operations or use of onboard APUs), other airfield operations (engine ground running), and airside ground support equipment (GSE) and vehicles required to handle an aircraft turnaround[25]. Also excluded from this assessment are the GHG emissions associated with all other landside or terminal activities which were the subject of the 2016 EIS.

The assessment of activities and phases of flight involving aircraft engine use presented in this technical paper are shown in Figure 6.1. For clarity, emissions of CO_2e from all ground-based operations on the Airport Site related to combustion of Jet A-1 fuel and aviation gasoline by aircraft main engines are excluded from this assessment. This includes all pre-departure and post-arrival activities, taxiing (inbound and outbound) and maintenance-repair-overhaul activities.

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[25] A turnaround is the process and time elapsed to handle and service an aircraft when it is parked at a gate between flights. Core activities performed in a turnaround include the offloading/loading of cargo and passengers, cabin cleaning and waste collection, airframe and system inspections, refuelling, catering and resupplying, etc. Turnarounds vary between short-haul and long-haul flights. Short-haul flight turnarounds can be as fast as 25-30 minutes in duration. Long-haul flight turnarounds normally require between 90-180 minutes.

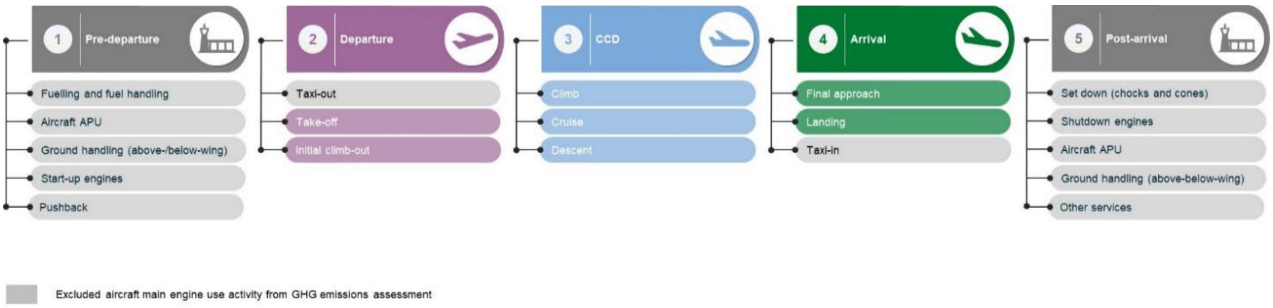

Figure 6.1 Aircraft engine use activities assessed

6.2 Previous assessment

In April 2014, the Australian Government announced that Badgerys Creek would be the location of a new airport for Western Sydney. The development of a completely new airport at Badgerys Creek was the subject of an EIS which was finalised in 2016. In December 2017, the Minister for the Environment under Section 96B(3)(a)(ii) of the *Airports Act 1996* (Airports Act) (Cth) gave notice to the Minister for Infrastructure (at 2017), stating that specified conditions and provisions should be included in the Airport Plan for the Stage 1 Development of WSI for the purpose of protecting the environment. Development approval for Stage 1 Development of WSI including the airfield, terminal and landside layout and facilities are set out in the Airport Plan determined under the Airports Act (Cth).

The 2016 EIS assessed proof of concept flight paths that have since been disregarded for a clean sheet of paper approach. As a result, in accordance with conditions of the Airport Plan and requirements of the EPBC Act (Cth), the finalised preliminary design of flight paths, airspace changes, air traffic control procedures and noise abatement procedures for WSI is required to be assessed.

Impacts of the Stage 1 Development on GHG emissions were quantified in tonnes of CO_2e for construction and operation of the Stage 1 Development. The findings of this assessment were presented in the 'Western Sydney Airport EIS Local Air Quality and Greenhouse Gas Assessment' (Pacific Environment Limited 2016) (Appendix F of the 2016 EIS). The GHG assessment was undertaken in accordance with the EIS guidelines and considered various operational impacts including those associated with the emissions of aircraft engine use.

6.3 Assessment study boundary

The study boundary determines the sources of emissions to be included in this assessment and those that are excluded. In this assessment, the CO_2 emissions boundary is set with reference to the methodology described in the GHG Protocol and ISO 14064-1:2018. Engine power (thrust) is used by aircraft engines to propel the aircraft forward during the take-off roll and, in the airspace below 10,000 ft (3,048 m), to climb from or descend to an airport and for flights departing from WSI to all destination airports across its anticipated route network. This is the only source of GHG emissions assessed in this technical paper. Aircraft engines are classified as either gas turbine turbofans or turbo-prop engines fuelled with aviation kerosene (i.e., commonly referred to as Jet A-1 fuel).

The results of the GHG emissions modelling are presented as total aggregated emissions in both assessment years (2033 and 2055), representing the anticipated GHG emissions from the mix of aircraft-engines scheduled to use the new flight paths introduced for WSI.

Full flight emissions of CO_2 from the operation of aircraft engines were estimated for all projected departures to each destination airport across the anticipated WSI route networks in 2033 and in 2055.

The study boundary extents for this assessment vary and include:

- up to 10–12 nm (around 19–22 km) from WSI to account for GHG emissions from aircraft engine use in the LTO cycle (below 3,000 ft (914 m) in altitude) as defined by ICAO in Document 9889, Air Quality Guidance Manual (latest edition)
- up to 20–22 nm (around 37–43 km) from WSI to account for GHG emissions from aircraft engine use in an extended C-D cycle (below 10,000 ft (3,048 m) in altitude)
- all one-way flights departing from WSI to destination airports varying in flight distances of less than 500 nm (926 km) to more than 4,000 nm (7,300 km).

Figure 6.2 shows the boundaries of aircraft engine use fuel burn and GHG emissions.

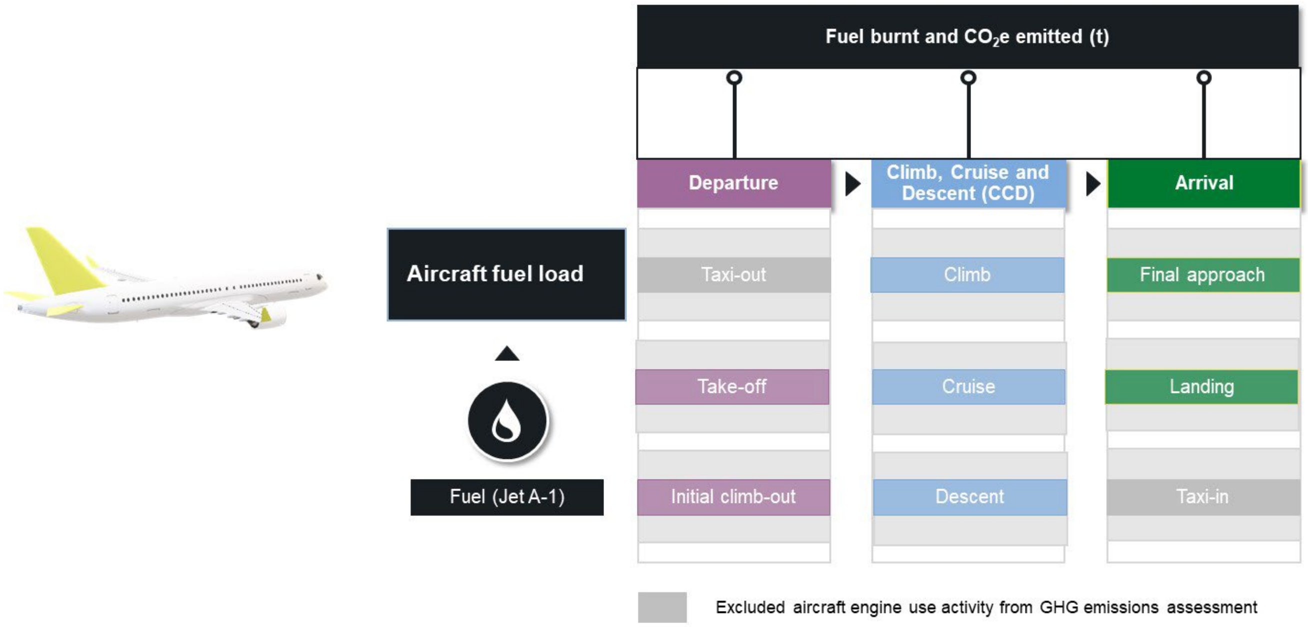

Figure 6.2 Aircraft engine use fuel burn and associated CO_2e emissions boundaries

6.4 Units and metrics

The results for this assessment were scaled to appropriate metrics to provide meaningful comparators of CO_2e emissions. These comparators are often defined as the 'functional unit' in carbon accounting. For this assessment, the following units for emissions are presented:

- total CO_2e emissions for all phases of flight (both arriving and departing) below 3,000 ft (914 m)
- total CO_2e emissions for all phases of flight (both arriving and departing) below 10,000 ft (3,048 m)
- total CO_2e emissions (expressed in tCO_2e or Mt CO_2e): all projected flight emissions from aircraft departing WSI to each destination airport across WSI's anticipated route network.

6.5 Methodology

This section details the methodology used to calculate the tailpipe CO_2e emitted in the exhaust behind the aircraft from engine use projected to occur due to single runway operations (05/23) at WSI.

GHG emissions from an individual aircraft are a function of 3 main parameters:

1. Time in mode (TIM) is the time, usually measured in seconds, that the aircraft engines operate at an identified power (thrust) setting in one of flight phases identified in the assessment.
2. Aircraft engine fuel flow is the unit mass of fuel burned, kilograms of fuel, for a specific engine in each phase of flight identified in the assessment.
3. Aircraft engine emission index (EI) is the units of CO_2 emitted per kilogram of fuel burned. Multiplying the mode-specific EI (3.16) by the TIM-specific fuel flow yields a mode-specific CO_2 rate in units of kilograms or tonnes per second.

The energy content factor and EI for kerosene for use as fuel in an aircraft (Jet A-1) was derived from the Australian Government's National Greenhouse Accounts Factors 2022 (DCCEEW) as shown in Table 6.1.

Table 6.1 Estimation of CO_2e emissions from Jet A-1 fuel use in aircraft engines

Energy content factor	Scope 1 EI (kgCO_2e/GJ)				Scope 3 EI
GJ/kL (unless otherwise indicated)	CO_2	CH_4	N_2O	Combined gases	kgCO_2e/GJ
36.8	69.6	0.01	0.6	70.21	18

Based on the figures in Table 6.1, an EI of 3.22*** kgCO_2e per kg of Jet A-1 where the assumed density of Jet A-1 is 0.8 kg per litre. This EI was used to estimate CO_2e emissions from aircraft engine use in 2033 and 2055.

The aggregation of CO_2 and CO_2e emissions from the WSI scheduled demand projections provided by WSA Co also include 2 additional parameters:

1. fleet size and mix
2. number of operations.

Figure 6.3 illustrates the approach employed to calculate the aircraft tailpipe CO_2 and CO_2e emissions in different phases of flight from aircraft using WSI's flight paths and route network.

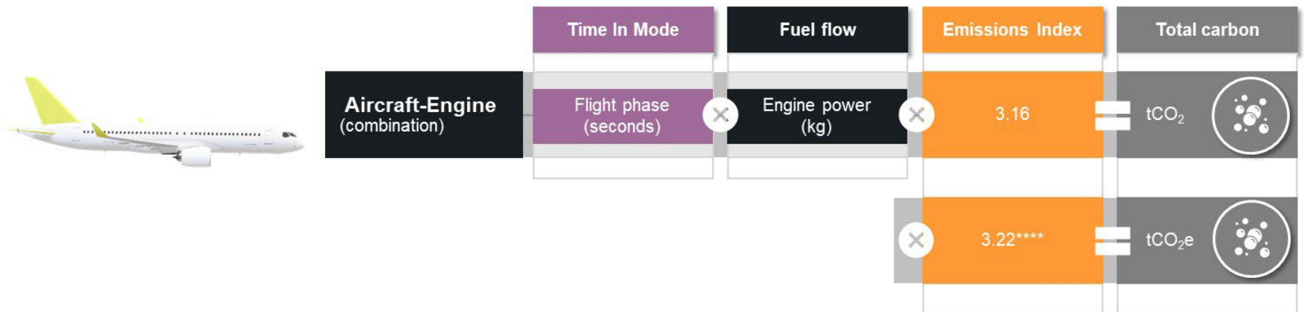

Figure 6.3 Calculation approach for aircraft tailpipe CO_2 and CO_2e emissions

6.5.1 Model platform

The aircraft tailpipe CO_2e emissions calculations in this assessment are based on projected fuel consumption on a per-flight basis. For any given flight, to determine at which point monitoring of fuel consumption starts and ends (including subsequent calculations), rules have been set to align with specific phases of flight in the LTO cycle below 3,000 ft (914 m), an extended C-D cycle below 10,000 ft (3,048 m) and for full flight emissions (WSI departures only). The calculation is aircraft-engine type-specific, reflecting the average fuel burn and related CO_2e emissions of each aircraft type in the demand schedules provided by WSA Co.

The model platform used to calculate CO_2 and CO_2e emitted in the exhaust behind the aircraft engines along WSI's flight paths and route network is shown in Figure 6.4.

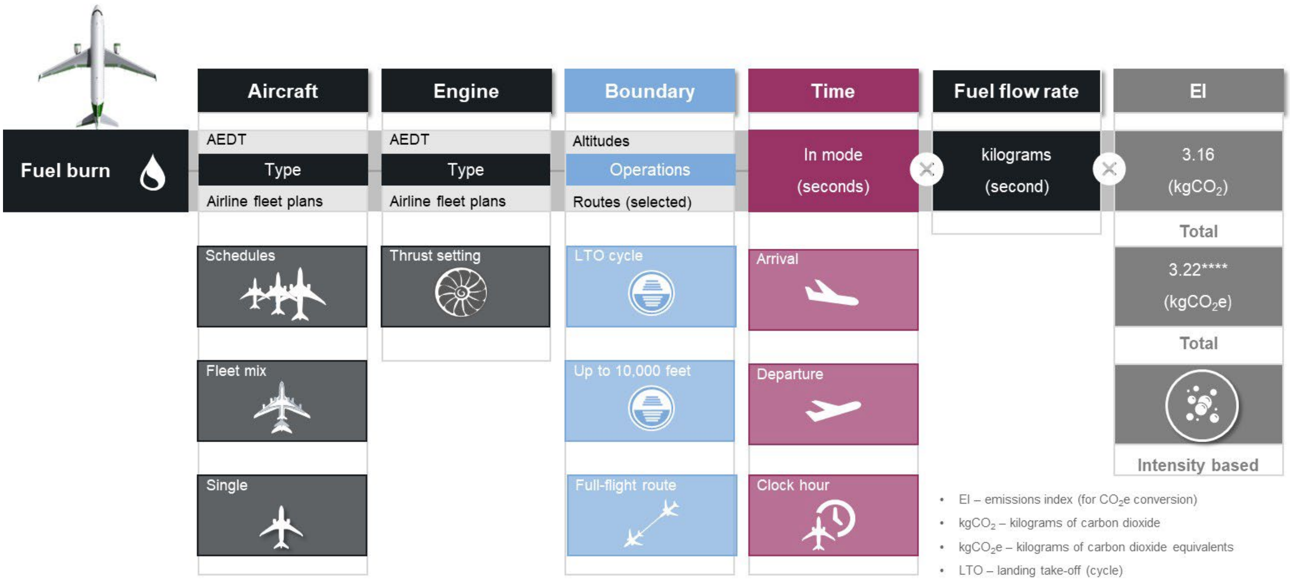

Figure 6.4 CO_2 and CO_2e emissions model platform for aircraft engine emissions

6.5.2 Main data sources

The organisations in Table 6.2 provided the framework and data used in the modelling of tailpipe CO_2 and CO_2e emissions from aircraft engine use for the preliminary airspace design.

Table 6.2 Main input data and sources

Parameter	Value	Source
AEDT model	Version 3e	US FAA
Forecast schedule demand	2033, 2055	WSA Co (representative average week for Northern Summer (NS) and Northern Winter (NW))
Aircraft fleet mix	2033, 2055	WSA Co
Aircraft engines	Types (various)	AEDT Version 3e database, selected airline fleet plans and the ICAO AEED Version 29
Representative aircraft	10-types	Airbiz in consultation with the DITRDCA (single event emission signatures for most operated aircraft ranging from turbo-props to wide-body jets)
Flight paths	Runway 05 or Runway 23	Technical Working Group (advisors to the DITRDCA)

Parameter	Value	Source
Runway operations	Modes	Airbiz in consultation with the DITRDCA/Airservices Australia (operational scenarios based on meteorological and schedule analysis)
Runway reference points	Coordinates	DITRDCA (heights above mean sea level)
Meteorology	Various	Bureau of Meteorology (BoM)

6.5.3 Aircraft fleet inventories

Table 6.3 shows the mix of aircraft types in the schedules provided by WSA Co Tailpipe CO_2e emissions in the exhaust behind the aircraft were modelled for engine use. Calculations of CO_2e emissions relied on the aircraft-engine assignments currently available in the AEDT Version 3e and ICAO's Aircraft Engine Emissions Databank (AEED) Version 29 databases, as appropriate. The AEED contains information on exhaust emissions by aircraft engines certified and measured according to the parameters in ICAO Annex 16 – Environmental Protection -Volume II – Aircraft Engine Emissions, Fourth Edition, July 2017. Currently excluded from the model outputs are CO_2e emissions for 2 aircraft, the SAAB SF3 and Airbus A220. Appropriate substitutions were assigned to account for the CO_2e emissions produced by these 2 aircraft types.

Table 6.3 Aircraft inventories in 2033 and in 2055

Aircraft types (scheduled)	Aircraft class	**2033** (daily movements)		**2055** (daily movements)	
		Number	%	Number	%
DH4	Non-jet	12.86	5.78	12.86	2.06
SF3	Non-jet	4.00	1.80	12.00	1.93
A220	Jet	21.14	9.51	19.00	3.05
A320neo	Jet	46.00	20.69	125.86	20.21
A321neo	Jet	29.43	13.24	67.43	10.83
B73H	Jet	12.00	5.40		
B738	Jet	59.14	26.61	61.14	9.82
B73M8	Jet	8.57	3.86	127.14	20.41
B739	Jet			2.00	0.32
A332	Jet	4.00	1.80		
A333	Jet	6.57	2.96	35.43	5.69
A33F	Jet	3.14	1.41	4.29	0.69
A339	Jet	1.43	0.64	9.71	1.56
A359	Jet	2.00	0.90	26.57	4.27
A351	Jet			20.00	3.21
A35F	Jet			2.57	0.41
B77W	Jet	2.00	0.90	16.00	2.57

Aircraft types (scheduled)	**Aircraft class**	**2033** (daily movements)		**2055** (daily movements)	
		Number	**%**	**Number**	**%**
B779	Jet			16.00	2.57
B77F	Jet	3.43	1.54	2.57	0.41
B788	Jet	3.43	1.54	30.00	4.82
B789	Jet	2.57	1.16	30.86	4.95
B748F	Jet	0.57	0.26	1.43	0.23
TOTAL	**22**	**222** (rounded)	**100**	**623** (rounded)	**100**

The numbers of average daily movements (arrivals plus departures) were calculated by taking the weekly schedules provided by WSA Co and dividing by 7, and similarly weighting for the NS and NW schedules. For modelling it is assumed that separate arrivals and departures numbers were calculated by dividing movements by two. As only weekly schedules were provided for NS and NW, the annualised numbers simply multiply the average day by 365.

Generally longer flights operated by wide-body jets (WBJ) carry more fuel on departure, resulting in higher engine power (thrust) settings and shallower climb profiles. The combination of these factors means that the departure phases of longer flights typically emit more CO_2 than shorter flights operated by narrow-body jets (NBJ) or non-jets (NJ) (i.e., turbo-props (TP)). The CO_2 and CO_2e emitted by arriving aircraft in the final approach phase of the LTO cycle are generally independent of the distance flown because minimal engine power (thrust) is required, with much of the fuel load consumed.

In the AEDT modelling program, departures are defined for several 'stage lengths', representing different flight distances to the destination airport. The CO_2e emitted for a full flight have been calculated for various stage lengths for each aircraft type using the methodology from ICAO's Carbon Emissions Calculator (Version 11, June 2018). Table 6.4 presents the various AEDT departure stage lengths for all flight routes to each destination airport to calculate full flight emissions.

Table 6.4 Stage lengths for full flight emission calculations

Stage length	Distance to destination airport in nautical miles		Typical destination from schedule
	From	To	
1	0	500	ABX, ARM, AVV, BNE, BNK, CBR, CFS, DBO, LST, MEL, MCY, MQL, OAG, OOL, PQQ, TMW, WTB
2	500	1,000	ADL, HBA, HTI, ROK, TSV
3	1,000	1,500	AKL, ASP, AYQ, CHC, CNS, NOU, VLI, WLG, ZQN
4	1,500	2,500	APW, DPS, DRW, NAN, PER, SUV
5	2,500	3,500	BPN, BWN, CGK, GUM, MNL, RAR, SIN
6	3,500	4,500	BKK, CAN, CSX, DMK, HAK, HAN, HKG, HKT, HND, HNL, ICN, KIX, KUL, NGO, NRT, PVG, SGN, SZX, TPE
7	4,500	5,500	BOM, CGO, CKG, CMB, CTS, CTU, PEK, MRU, TAO, XIY
8	5,500	6,500	DEL, DWC, DXB, EZE, JNB, KHI, SCL, SFO
9	Over 6,500		BAH, DFW, DOH, IST, LAX, LHR

From the runway operating modes (RMOs), the runway allocation is determined along with the designated track allocation by applying the appropriate distributions. Forecast schedules were provided by WSA Co, the operator of WSI, for both the NS and NW. These schedules list all aircraft operations for a representative average week and were supplied for 2033 (represents the early years of WSI operations) and 2055 (represents the year when single runway operations are expected to be operating at near capacity). They included details on type of aircraft, type of operation type (arrival or departure) and the scheduled origin-destination airport for each operation. These schedules are the basis of all aircraft tailpipe CO_2e emissions modelling described below.

6.5.4 Aircraft LTO cycle below 3,000 ft (914 m)

The ICAO has defined a specific reference LTO cycle below the height of 3,000 ft (914 m) above ground level for aircraft engine emissions certification (refer to ICAO Annex 16, Volume II, Aircraft Engine Emissions, Fourth Edition, July 2017 for additional information). The LTO cycle comprises 4 main phases of flight as shown in Table 6.5.

Table 6.5 The LTO cycle reference flight phases and times, engine power (thrust) settings

Flight phase	Time in mode (TIM) (minutes)	Engine power (thrust) setting (percentage of rated thrust)
Take-off roll	0.7 (42 seconds)	100
Initial climb	2.2 (132 seconds)	85
Approach	4 (240 seconds)	30
Taxi and ground idle	26 (1,560 seconds) Inbound 7 (420 seconds Outbound 19 (1,140 seconds)	7
Total	**32.9** (1,974 seconds)	**Variable** – dependent on phase of flights and conditions

The LTO cycle is intended to address aircraft operations below the atmospheric mixing height[26] or inversion layer. While the mixing height can vary from location to location, on average it extends to a height of approximately 3,000 ft (914 m). It is visualised in Figure 6.5.

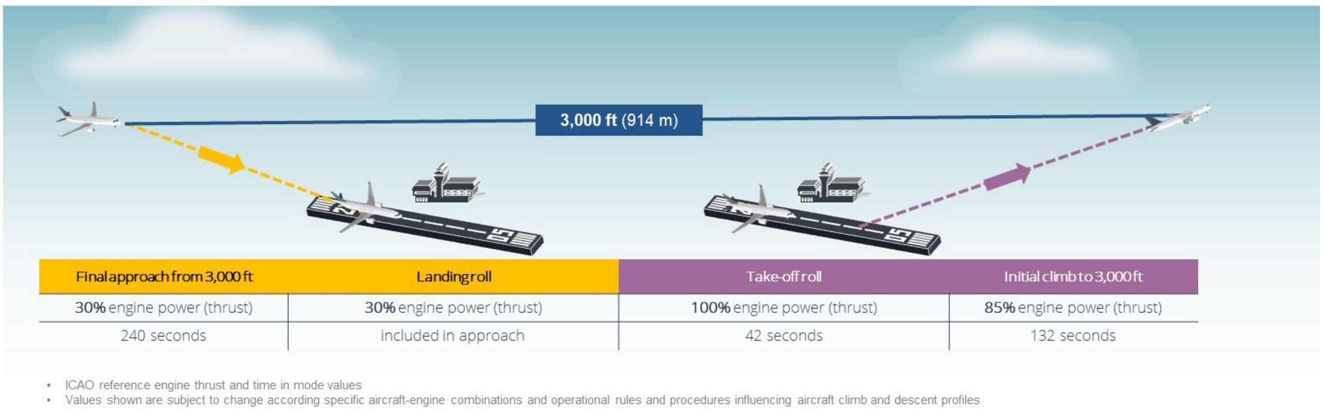

Figure 6.5 The LTO cycle

26 The mixing height refers to the atmospheric 'boundary layer' or 'mixing layer'. It is characterised by turbulence and the mixing of air which varies in height according to the local cloud base. When aircraft fly at low altitudes, typically up to 3,000 ft above ground level, emissions will be dispersed and potentially brought to ground due to large-scale circulations and air mixing.

GHG emissions associated with aircraft engine use in the LTO cycle were calculated using the US FAA's AEDT model, Version 3e. All aircraft in the full (average weekly) demand schedules provided by WSA Co for 2033 and 2055 were modelled. Output files from AEDT were post-processed to allocate CO_2e emissions from the aircraft movements listed in Table 6.4. The CO_2 and CO_2e emission values were determined from the appropriate emissions factors for the combustion of aviation fuel (Jet A-1).

As mentioned, the CO_2 and CO_2e emissions estimated in both assessment years (2033 and 2055) do not include inbound and outbound taxi operations on the ground between aircraft parking positions and the runway. Due to uncertainties on the efficiency, scale and timelines for the introduction of innovative new aircraft and propulsion technologies and use of SAF, associated reductions of CO_2e were excluded from this assessment.

Where the value for CO_2e is not a whole number, the number is rounded up to the next whole number if the number at the first decimal place equals or exceeds five (5). It is rounded down to the next whole number if the number at the first decimal place is less than five (5).

6.5.5 Extended C-D cycle below 10,000 ft (3,048 m)

The same approach used to calculate aircraft tailpipe CO_2e emissions in the LTO cycle below 3,000 ft (914 m) is adopted to calculate these emissions in an extended C-D cycle below 10,000 ft (3,048 m). The extended cycle captures emissions of CO_2e from additional phases of flight as aircraft climb to 10,000 ft (3,048 m) or descend from this altitude to their landing threshold.

In this assessment, CCD is defined as all activities that take place above 10,000 ft (3,048 m). No upper limit of altitude is given. CCD includes the climb all the way up to the cruise altitude, the cruise phase of flight and the descent from the cruise altitude to the start of the arrival phase at 10,000 ft (3,048 m). Aircraft tailpipe emissions for phases of flight in the CCD are assessed as full flight emissions (refer to Section 6.5.7).

6.5.6 Aircraft single event emissions below 10,000 ft (3,048 m)

Accompanying the LTO cycle and an extended C-D cycle below 10,000 ft (3,408 m) cycle CO_2e emissions calculations, are single event aircraft tailpipe CO_2e emission calculations for the 10 most common aircraft types anticipated to operate in the 2033 and 2055 fleets. These were created to compare the tailpipe CO_2e emissions on a single event basis for each aircraft type. Table 6.6 shows the representative aircraft used to calculate these single event CO_2e emissions. They account for around 80 per cent and 81 per cent of total daily fleet movements projected in 2033 and in 2055, respectively.

Table 6.6 Representative aircraft types for single event CO_2 emission calculations

Aircraft	ICAO designator (aerodrome ref. code)	Manufacturer	Engine (type)	2033 (daily movements)	2055 (daily movements)
A221	Code 4C	Airbus	CFM56-3C-1	21.14	19.00
A322*	Code 4C	Airbus	V2527-A5	46.00	125.86
A321neo	Code 4C	Airbus	V2533-A5	29.43	67.43
B738	Code 4C	Boeing	CFM56-7B27	59.14	61.14
B7M8	Code 4C	Boeing	LEAP-1B27	8.57	127.14
A333	Code 4E	Airbus	CF6-80E1A3	6.57	35.43
A359	Code 4E	Airbus	Trent XWB-84	2.00	26.57
B77W	Code 4E	Boeing	GE90-115B	2.00	16.00
B789	Code 4E	Boeing	GEnx-1B74/75/P2	2.57	30.86
B748F	Code 4F	Boeing	Genx-2B67/P	0.57	1.43
TOTAL				**178** (rounded)	**505** (rounded)
Percentage (%) of total fleet mix covered				**80** (rounded)	**81** (rounded)

*The values shown in the above table for the Airbus A320-200 aircraft type will be updated with new values for the next-generation Airbus A20N when a discrepancy in the AEDT model suite is resolved.

6.5.7 Full flight emissions

The methodology from ACI's Airport Carbon Accreditation Application Manual (Issue 13, March 2023) and the ICAO Carbon Emissions Calculator (Version 11.1, June 2018) were used to calculate full flight emissions for aircraft departing from WSI to all destination airports across its anticipated route network in 2033 and 2055. Each departing flight in the projected demand schedules provided by WSA Co, including the individual aircraft types and flight distances to each destination airport were modelled. Calculations were made of individual aircraft fuel consumption according to the destination airport they were flying to using the adjusted Great Circle Distance (GCD).

A distance-based approach was used to estimate full flight emissions for all regional, domestic and international departure routes to destination airports shown in Table 6.2. The full flight emissions were calculated for each aircraft type in the 2033 and 2055 schedules. Aircraft were mapped to their allocated route according to the distance between WSI and the destination airport. For international routes, the GCD[27] between WSI and the destination airport was accounted for. The average fuel consumption of each flight relied on ICAO's fuel consumption formula (i.e., kg of fuel consumed per km travelled by aircraft type). The resultant fuel burn was then multiplied by 3.16 (the EI) to estimate the amount of CO_2 emitted. All aircraft fuel was assumed to be kerosene (Jet A-1). Energy content factors from the National Greenhouse Accounts Factors (DCCEEW 2022) were used to estimate CO_2e emissions.

To account for the GCD, flight distances were adjusted to reflect the airways inefficiencies (plus 27 nm (50 km) when the GCD less than 540 nm (1,000 km), plus 54 nm (100 km) when the GCD was less than 5,400 nm (10,000 km) and plus 81 nm (150 km) otherwise) as per ICAO's approach. These adjusted distances were then used to determine aircraft fuel burn rates and using the EI (3.16) converted into emissions of CO_2. On capturing all the emissions of CO_2 for a single flight along each route, each aircraft is multiplied by the number of movements allocated in the 2033 and 2055 schedules provided by WSA Co.

The results of the aircraft engine GHG emissions modelling have been presented as total aggregated emissions in both assessment years (2033 and 2055), representing the anticipated tailpipe CO_2e GHG emissions produced in the engine exhaust behind the aircraft using WSI's flight paths to destination airports across its anticipated route network.

6.6 Airservices Environmental Management of Changes to Aircraft Operations National Operating Standard

The fuel burn and emissions criteria set out in the Airservices Environmental Management of Changes to Aircraft Operations National Operating Standard (AA-NOS-ENV2.100 Version 18 Effective 01 July 2022) was applied to the assessment of GHG emissions in this technical paper.

AEDT modelling was used to calculate projected fuel burn and CO_2 and CO_2e emissions below 10,000 ft in altitude for WSI in 2033 and in 2055.

The results of this modelling are included in Chapter 8 of this technical paper.

[27] GCD (Great Circle Distance) is the distance between origin and destination airports is derived from latitude and longitude coordinates originally obtained from ICAO Location Indicators database.

6.7 Assumptions and technical limitations

In preparing this study, Airbiz has relied upon data, surveys, analyses, designs, plans and other information provided by the DITRDCA and other individuals and organisations. Except as otherwise stated in this assessment, Airbiz has not verified the accuracy or completeness of the data. To the extent that the statements, opinions, facts, information, conclusions and/or recommendations in this assessment (conclusions) are based in whole or part on the data, those conclusions are contingent upon the accuracy and completeness of the data. Airbiz will not be liable in relation to incorrect conclusions should any data, information or condition be incorrect or have been concealed, withheld, misrepresented or otherwise not fully disclosed to Airbiz.

To the best of Airbiz's knowledge, the analysis presented and the facts and matters described in this assessment reasonably represent the DITRDCA's intentions at the time of preparation of this technical paper. However, the passage of time, the manifestation of latent conditions or the impact of future events (including a change in applicable law) may result in a variation of the project and its possible environmental impact. Airbiz will not be liable to update or revise this report to consider any events or emergent circumstances or facts occurring or becoming apparent after the date of the report.

For this GHG emissions assessment, aircraft engine use for the following flight activities is **excluded**:

- emergency response, including search and rescue
- head of state and government ministers
- helicopters (out of scope with no such operations expected at WSI)
- hold downs and altitude level-offs
- holding patterns
- maintenance
- media
- medivac
- military
- missed approaches and go-arounds
- training.

The operations listed above would likely constitute less than one per cent of total CO_2 emissions and are not considered material to the outcomes of this assessment.

Full flight emissions for aircraft departing origin airports across WSI's route network to WSI were excluded from this assessment. This approach was adopted to:

- avoid double counting with full flight emissions calculations of origin airports (i.e., full flight emissions budgets of each airport are underpinned by one-way flights (departures) from the origin to the destination airport or the halfway approach, where half of the flight to and half of the flight from the destination airport is accounted for, by the origin and destination airports respectively)
- align with the methodology from ACI's Airport Carbon Accreditation Application Manual (Issue 13, March 2023) to calculate full flight emissions
- ensure domestic aviation emissions are calculated and captured as part of Australia's Paris Agreement target while international aviation emissions are dealt with separately as part of Australia's involvement in ICAO.

A RFI was not applied given the scientific uncertainties that continue to surround its exact impact, and until consensus is reached by the global scientific community in terms of the value(s) that must be used.

Non-CO_2 emissions caused by contrails, occasional formations of cirrus clouds, oxides of nitrogen (NOx), soot and oxidised sulphur and their climate impacts have not been assessed. These emissions result in changes to the chemical composition of the global atmosphere and cloudiness, disrupting the earth-atmosphere radiation budget. Their precise impact (cooling and heating) under specific conditions to determine Effective Radiative Forcing is complex and uncertain.

The global scientific community continues to evaluate appropriate ways to calculate and measure wide ranging physical processes in the atmosphere, including air movement patterns, chemical balances and transformations, microphysics and radiation.

AEDT outputs produced for this assessment are presented in direct CO_2 emissions only. AEDT does not output values for CH_4 and N_2O emissions associated with the combustion of kerosene in aviation fuel (i.e., Jet A-1). The estimation of CO_2e emissions from the use of Jet A-1 fuel in engines operated by different aircraft types has relied on the emission factors published in the National Greenhouse Accounts Factors 2022 (DCCEEW 2022).

Chapter 7 Facilitated airspace changes

The Sydney Basin airspace is likely the busiest and most complex in Australia.

According to Airservices Australia, in calendar year 2019[28], more than 700,000 aircraft movements were recorded at Sydney (Kingsford Smith) Airport, Bankstown and Camden Airports in the Sydney Basin airspace. The actual flight paths of individual aircraft within the Sydney Basin airspace are recorded by Airservices Australia using information from surveillance radars operated by air traffic control.

Most parts of the Sydney Basin including Western Sydney and the GBMA currently experience some level of daily aircraft overflight activity. Figure 7.1 provides a one-week snapshot from March 2019 of aircraft movement activity on existing flight paths in the Sydney Basin for Sydney (Kingsford Smith), Bankstown and Camden Airports and Royal Australian Air Force (RAAF) Base Richmond. It shows that much of the GBMA, is also currently already overflown by a range of aircraft from existing airports including Sydney (Kingsford Smith) Airport (being the dominant source of aircraft activity) in addition to Bankstown and Camden Airports, and RAAF Base Richmond.

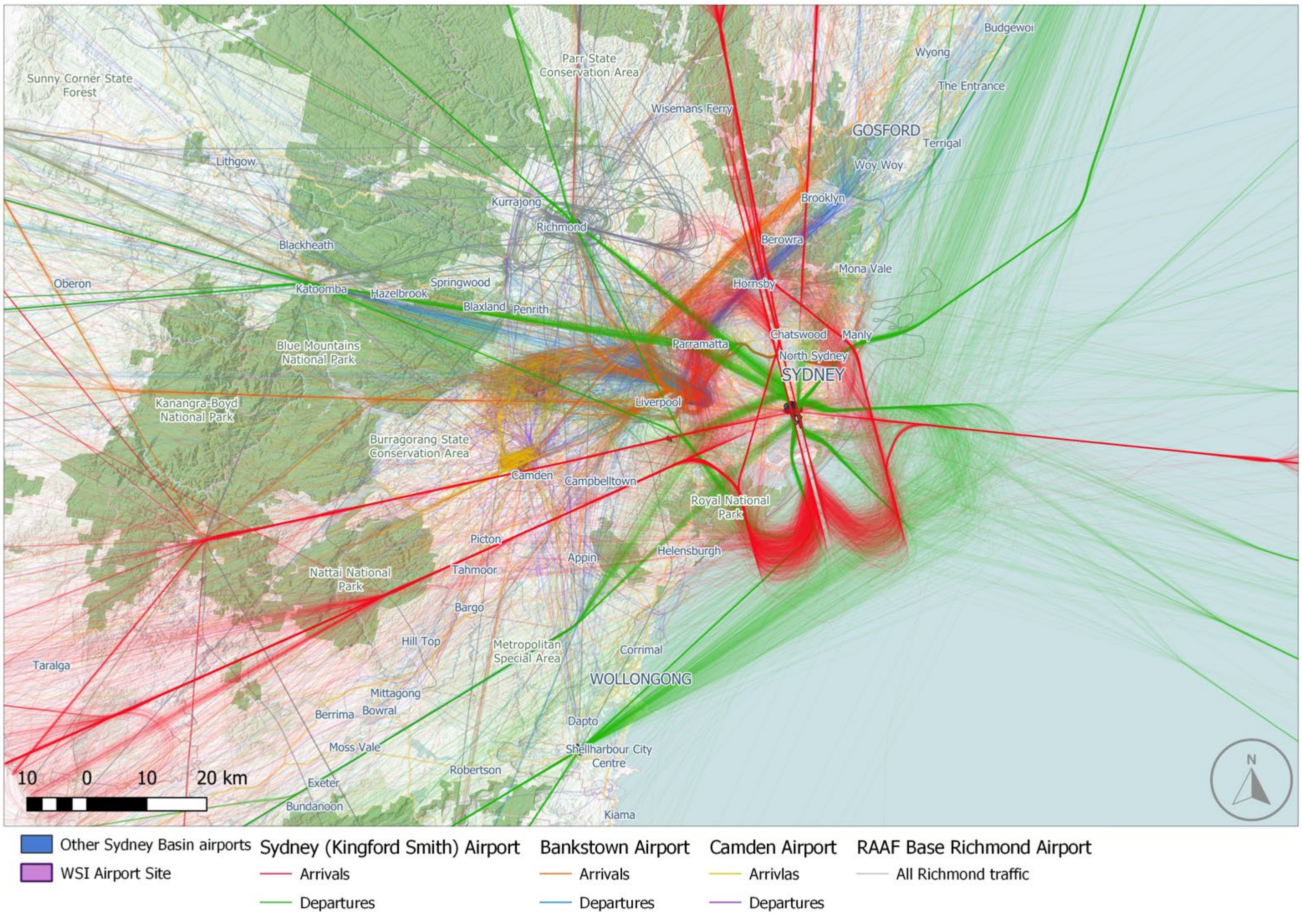

Figure 7.1 Sydney Basin airspace snapshot with 1-week of flight path activity in March 2019

28 Airservices Australia, Movements at Australian Airports – 2019 Calendar Year Totals)

The introduction of new flight paths to be used by aircraft into and out of WSI has considered a multitude of factors to minimise any changes to existing flight paths in the Sydney Basin. As each iteration of the preliminary airspace design for WSI was worked through it became evident that to maintain the safety assurance of flight operations in the Sydney Basin airspace. In doing so, other requirements had to be met for efficiency, capacity and environment, with some changes generally of a minor nature necessary to some of the existing SIDs and STARs in use at Sydney (Kingsford Smith), as well as changes to Instrument Flight Rules (IFR) and Visual Flight Rules (VFR) operations at Bankstown and Camden Airports, and RAAF Base Richmond, and changes to low altitude transit flights below 10,000 ft (3,048 m).

The adjustments required to Sydney Basin operations prior to the opening of WSI in 2026 are necessary to facilitate its flight paths and airspace structure. Any changes proposed and associated impacts to the flight paths at other aerodromes to accommodate aircraft operations from WSI have been considered in terms of safety, national security (Defence), efficiency, equity of airspace access, existing aircraft operating standards, as well as environmental and community impacts.

Facilitated airspace changes within the Sydney Basin airspace will be required prior to the opening of the WSI in 2026. These early changes are required to the vertical and lateral flight path profiles for aircraft arriving and departing from other neighbouring airports such as Sydney (Kingsford-Smith) Airport, Bankstown and Camden and the RAAF Base Richmond to maintain the safe separation of aircraft. These facilitated airspace changes are required prior to the opening of WSI in 2026 and will be staged to minimise the likelihood of conflicts or incidents.

The facilitated airspace changes will include adjustments to:

- Sydney (Kingsford Smith) Airport Runway 25 (jet) SIDs to the west, north-west and east
- Sydney (Kingsford Smith) Airport Runway 34L KADOM and RICHMOND (jet) SIDs
- Sydney (Kingsford Smith) non-jet SID to west and north-west
- Sydney (Kingsford Smith) Airport AKMIR STAR for jets and non-jets from the south and west
- Sydney (Kingsford Smith) Airport Runway 07 SID and IAF
- Bankstown Airport IFR operations (SID and STARs)
- Camden Airport STARs
- RAAF Base Richmond SID and STARs
- Sydney Basin VFR operations
- Miscellaneous and minor procedure adjustments (i.e., Sydney (Kingsford Smith) Airport BOREE and RIVET STARs, Sydney (Kingsford Smith) Airport Runway 07 SID and IAF, and Sydney Basin low altitude transit flights.

Some of these adjustments required to Sydney Basin operations will extend or shorten flight paths. As assessment of the potential impacts resulting from the facilitated airspace changes on track distance and associated GHG emissions has been undertaken and is presented in Technical paper 13: Facilitated changes (Airbiz 2023) (Technical paper 13), as appropriate. For adjustments that extend or shorten a flight path by less than 1 nm (1.852 km) no assessment of aircraft tailpipe CO_2e emissions was undertaken.

Chapter 8 Impact assessment

8.1 Overview

Aircraft engines produce GHG emissions with a significant proportion emitted at high altitudes during the cruise phase of flight. GHG emissions in the exhaust plumes behind aircraft engines during all phases of flight alter the atmospheric concentration of GHGs, trigger the formation of condensation trails (contrails) and occasional cirrus clouds all of which contribute to climate change. Against this backdrop, the CO_2e emissions from aircraft using WSI's flight paths were assessed by estimating the distinct contribution that they could make to emissions from a UNFCCC participating nation or sector – in this case Australia and its commercial aviation sector.

Throughout this chapter, tailpipe CO_2e emissions from the operation of aircraft engines using WSI's flight paths are compared to historic economy wide emissions trends reported by the Australian and NSW Governments alongside their commercial aviation sectors and outlooks projected in 2033 and in 2055 based on growth rates for domestic and international aviation activity (SAP 2017).

An efficient airspace system with supporting air traffic management procedures can deliver significant savings of fuel and CO_2e emissions. To ensure the environmental and operational efficiency of aircraft using airspace, 4 basic elements must be addressed and optimised:

- airspace route structure
- airspace management
- air traffic services
- air traffic flow management.

At WSI, every landing and take-off provides an opportunity to save fuel and reduce CO_2e emissions, if performed efficiently and within safety assurance parameters.

The fleet of aircraft expected to operate from WSI comprises aircraft of variable capability, performance and size. It can be difficult to design procedures that are optimised for an entire fleet of aircraft, and there is a tendency for procedures to be designed to accommodate less capable aircraft. Take-off and climb are the operations that require the greatest engine power (thrust) and hence the highest rate of fuel use and generation of aircraft engine CO_2e emissions.

When undertaking an assessment of aircraft tailpipe CO_2e emissions, it is important to understand the magnitude of variation in fuel burn between the different phases of flight. Fuel burn rates are much greater in climb compared to cruise where aircraft spend more time and travel the most distance, and in cruise compared to descent. Opportunities to reduce fuel burn should not be restricted only to those phases of flight with the highest fuel burn, but to all phases of flight including on the ground operations (i.e., taxiing between the runway and aircraft parking positions). CO_2e emissions from ground operations are excluded from this assessment. The duration (TIM) and engine power (thrust) setting of different phases of flight must be considered, as tangible fuel savings can be made even though differences in fuel burn rates are quite small.

A full load of fuel means the aircraft is heavier and will burn more fuel in the climb phase. This phase of flight is therefore important in terms of optimisation with any efforts to reduce inefficiency resulting in proportionately greater fuel and emissions savings. As the demand for aviation has grown in the Sydney Basin, airspace around airports like Sydney (Kingsford Smith), Bankstown and Camden have typically become busier, increasing the complexity of the airspace and its use. To manage this complexity, the preliminary airspace design for WSI has adopted "Safety by Design" principles. These are principles that deliver the highest level of safety separation assurance to ensure airspace design has focused on "Safety by Design", a process ensuring that traffic flows are de-conflicted by flying additional track distances and if required periods of level flight for climbing and descending aircraft.

This can result in aircraft climbing in a series of steps separated by periods of level flight to keep them separated at minimum safe altitudes from arrival traffic flows and aircraft from other airports. If departing aircraft are required to level off at low altitudes or climb at a speed below what is most operationally efficient, the pilots must employ flap settings that increase drag. Such flap settings require additional engine power (thrust) to maintain operational control of the aircraft, which increases the amount of fuel consumed and CO_2e emitted into the atmosphere. The preliminary airspace and flight path design for WSI focusses on maximising opportunities for Continuous Climb Operations (CCO) and Continuous Descent Operations (CDO) in the take-off, climb and descent phases of flight, minimising the requirements for low altitude segments of flight while adhering to the principles of “Safety by Design”.

8.2 Assessment years

The first full year of single runway operations at WSI is 2027. From 2027, single runway operations at WSI are anticipated to grow incrementally to handle up to 37 MAP and 226,000 annual air traffic movements by around 2055.

To assess the project’s future impacts from aircraft tailpipe GHG emissions, 2 assessment years are presented in the EIS and summarised below in Table 8.1. This assessment calculates aircraft tailpipe CO_2e emissions for the projected demand schedule and aircraft fleet mix expected to operate at WSI in 2033 and in 2055. An analysis of aircraft tailpipe CO_2e emissions along WSI’s flight paths and route network is presented in this chapter. To assess potential impacts comparisons have been made to historical economy wide GHG emissions reported by the Australian Government and NSW Government (Australian Greenhouse Gas Accounts – DCCEEW 2022). This has included the GHG emissions trends for the transport sector and commercial aviation activities.

Projections were made of economy wide, transport sector and commercial aviation activity GHG emissions out to 2055. These projections applied Australian Government growth factors for domestic and international aviation (SAP 2017) and were extrapolated beyond 2035 to 2055 to drive comparisons with WSI’s projected CO_2e emissions.

Table 8.1 Reference years for WSI operations

Planned activity level (PAL)	Reference year	Annual air traffic movements (passenger and freight)	Daily air traffic movements (passenger and freight)	MAP	Assessment type and where it is addressed in this report
1 Early years of operation	2033	81,190	222 (rounded down)	10	Quantitative – Chapter 8
3 Operating at near capacity	2055	227,499	623 (rounded up)	37	Quantitative – Chapter 8

8.3 WSI’s airspace and flight path emissions footprint

8.3.1 LTO cycle emissions below 3,000 ft (914 m)

Table 8.2 shows the estimated CO_2e emissions footprint in the LTO cycle (phases of flight below 3,000 ft (914 m) exclusive of inbound/outbound taxi operations on the ground) from projected aircraft movements in 2033. The projected growth in aircraft tailpipe CO_2e emissions in 2055 in WSI’s LTO cycle are also summarised.

The projected total LTO cycle emissions from the 81,190 aircraft movements projected to operate at WSI in 2033 is around 63,813 tonnes of CO_2e (tCO_2e) at an estimated carbon-intensity of 0.79 tCO_2e/ATM. This correlates approximately to the LTO cycle emissions reported at Adelaide Airport in 2019 of 69,049 tCO_2e from 103,115 flights or 0.67 tCO_2e/ATM carrying more than 8 million passengers. Adelaide Airport provides a useful comparison as its passenger throughput, operations and traffic numbers are within a similar range of WSI’s projected PAL in 2033. WSI’s LTO cycle does not account for emissions from inbound/outbound taxiing operations (on the ground) which can typically account for 25–40 per cent of a LTO cycle carbon footprint.

In 2055, total LTO cycle emissions of CO_2e are projected to increase to 220,331 tCO_2e at an estimated carbon-intensity of 0.97 tCO_2e/ATM. Air traffic movements are projected to increase by 146,309 movements (from 81,190 in 2033 to 227,499 in 2055) as WSI's single runway approaches capacity. Over 47 per cent of these flights are expected to operate services to international destinations. The proportion of higher fuel consuming WBJs operating on international and some domestic routes is anticipated to increase by 28 per cent compared to 2033 levels.

The initial climb-out phase of flight is responsible for more than 40 per cent of WSI's LTO cycle operational footprint in 2033 and in 2055. This is because aircraft are at the heaviest, carrying a full payload (i.e., the amount of belly hold cargo and passengers, transported and the fuel load configured for the flight and the fuel margins for a contingency alternate destination airport) and need to be configured under a high level of engine power (thrust) to create the lift required to get airborne.

Table 8.2 LTO cycle emissions of CO_2e below 3,000 ft (914 m) for all projected WSI aircraft movements in 2033 and in 2055

Flight phase	2033		2055	
	tCO_2e	% of emissions	tCO_2e	% of emissions
All aircraft movements from WSI in the demand schedules provided by WSA				
Take-off roll	18,200	28	64,974	29
Initial climb-out	27,989	44	98,172	45
Approach	15,115	24	49,859	23
Landing roll	2,508	4	7,326	3
Total	**63,813**	**100**	**220,331**	**100**

The results of the LTO cycle emissions calculations for WSI indicate the following:

- driven by primarily growth in international flights, LTO cycle emissions of CO_2e in 2055 were projected to grow significantly to 220,331 tCO_2e (without accounting for future aircraft fuel and operational efficiency improvements and technology advancements) when compared to 2033 levels of 63,813 tCO_2e
- emissions of CO_2e from domestic flights were projected to more than double in 2055, emitting around 66,834 tCO_2e up from 32,581 tCO_2e in 2033
- growth in international flights by 2055 was projected to increase by around 81,000 movements compared to 2033, accounting for around 47 per cent of all flight movements and almost 70 per cent of total emissions of CO_2e at 153,497 tCO_2e.

In 2019, the LTO cycle emissions reported at Sydney (Kingsford Smith) Airport were 431,445 tonnes of CO_2e, from 333,862 flights (or 1.29 tCO_2e/ATM) carrying more than 44 million passengers[29] (Sydney Airport 2022). By comparison, the estimated LTO cycle emissions from aircraft departing or arriving at WSI are anticipated to be significantly lower in absolute and intensity based CO_2e emissions for both 2033 and 2055.

[29] Sydney Airport Sustainability Report 2022

8.3.2 Extended C-D cycle emissions below 10,000 ft (3,048 m)

Table 8.3 shows the estimated CO_2e emissions footprint in an extended C-D cycle (all phases of flight below 10,000 ft (3,048 m) exclusive of taxi operations on the ground) from aircraft movements projected in 2033 and in 2055.

Table 8.3 Extended C-D cycle CO_2e emissions below 10,000 ft (3,048 m) for all WSI aircraft movements in 2033 and in 2055

Flight phase	2033		2055	
	tCO_2e	%	tCO_2e	%
All aircraft movements from WSI in the demand schedules provided by WSA				
Take-off roll	18,200	14	64,974	15
Initial climb-out	27,989	22	98,172	22
Extended climb	54,079	42	190,012	43
Descent from 10,000 ft	26,002	20	81,451	18
Landing roll	2,508	2	7,326	2
Total	**128,778**	**100**	**441,935**	**100**

The projected total emissions of CO_2e from all phases of flight in the extended C-D cycle below 10,000 ft (3,048 m) in 2033 are estimated to be around 128,778 tCO_2e from 81,190 flights. In 2055, these emissions of CO_2e are estimated to increase to approximately 441,935 tCO_2e from more than 227,000 flights. The carbon-intensity of WSI's flight operations is projected to increase to 1.9 tCO_2e/ATM, up 19 per cent when compared to 2033 levels of 1.6 tCO_2e/ATM.

The results of the extended C-D cycle emissions calculations for WSI indicate the following:

- driven by primarily growth in international flights, increased numbers of RPT services being operated by large WBJ on more medium to long haul routes, emissions of CO_2e were projected to grow significantly in 2055 to 441,935 tCO_2e up from 128,778 tCO_2e in 2033
- emissions of CO_2e from domestic flights were projected to more than double by 2055, emitting around 134,522 tCO_2e up from 66,462 tCO_2e in 2033
- growth in international flights by 2055 was projected to increase by 81,000 movements from 2033, accounting for around 47 per cent of all flight movements and almost 70 per cent of total emissions of CO_2e at 307,412 tCO_2e.

8.3.3 Full flight emissions

At all airports, flight paths and the RPT services they enable provide safe, efficient and critical business, medical and social connections. This is especially true on some flight routes that pass over water or where a land connection is difficult, or impossible but mostly this is a question of distance. For passengers and for high-value or perishable cargo[30], there is little or no alternative when travelling such long distances.

However, there is an environmental cost. Longer distances naturally mean longer duration flights, and mostly by larger WBJ aircraft. That results in significant cost in terms of emissions of CO_2e.

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30 High-value and perishable cargo includes pharmaceuticals and medical equipment, jewellery, cash and bonds, time-sensitive goods like flowers/fruits/meats/seafood/vegetables.

In 2033, all one-way flight departures operating from WSI to each of the 48 destination airports in the anticipated schedule were estimated to emit around 1.75 Mt CO_2e. Almost half of WSI's air traffic movements are anticipated to be short haul flights operating on routes of less than 500 nm (926 km). These flights however were only projected to account for 13 per cent of total emissions of CO_2e, approximately 0.42 Mt CO_2e. At the other end of the scale, long haul flights operating to destinations over 4,000 nm (7,408 km), represented 10 per cent of total flights but accounted for 39 per cent of total emissions of CO_2, approximately 0.70 Mt CO_2e (refer to Figure 8.1 comparing 2033 and 2055 modelling outcomes).

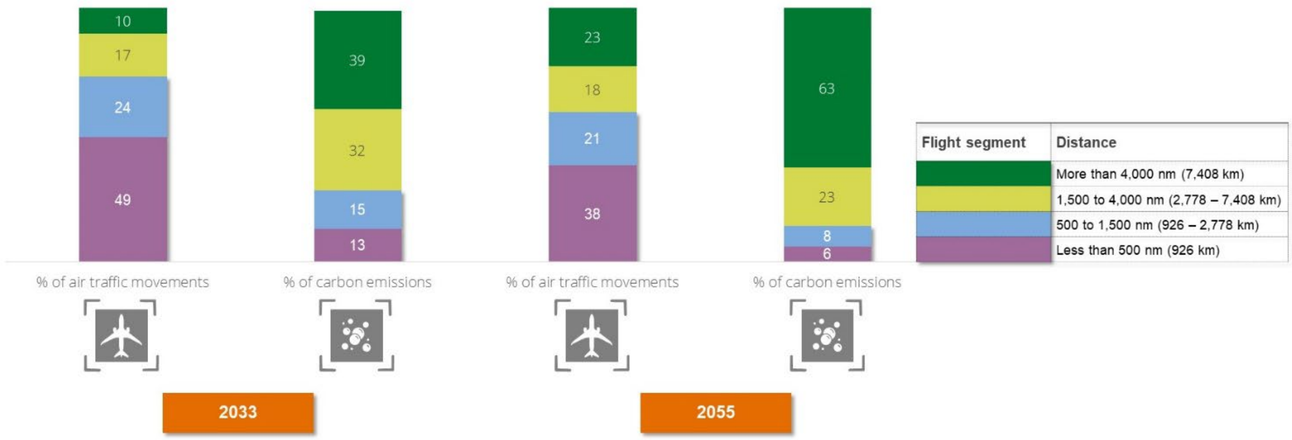

Figure 8.1 Apportionment of flight segments to emissions of CO_2

Figure 8.2 shows the full flight emissions of CO_2e estimated for all 40,595 flights departing WSI to the 48 destination airports across the anticipated WSI network. Four of the top 5 carbon emitting routes would be operated by international RPT services, the other being a domestic RPT service to Melbourne. A total of 12,053 departures (around 30 per cent of total movements in the schedule) operated on the top 5 carbon emitting routes and would be responsible for emitting 0.56 Mt CO_2e. This accounts for around 32 per cent of total flight emissions in 2033 at an average carbon intensity of 46.4 tCO_2e/ATM.

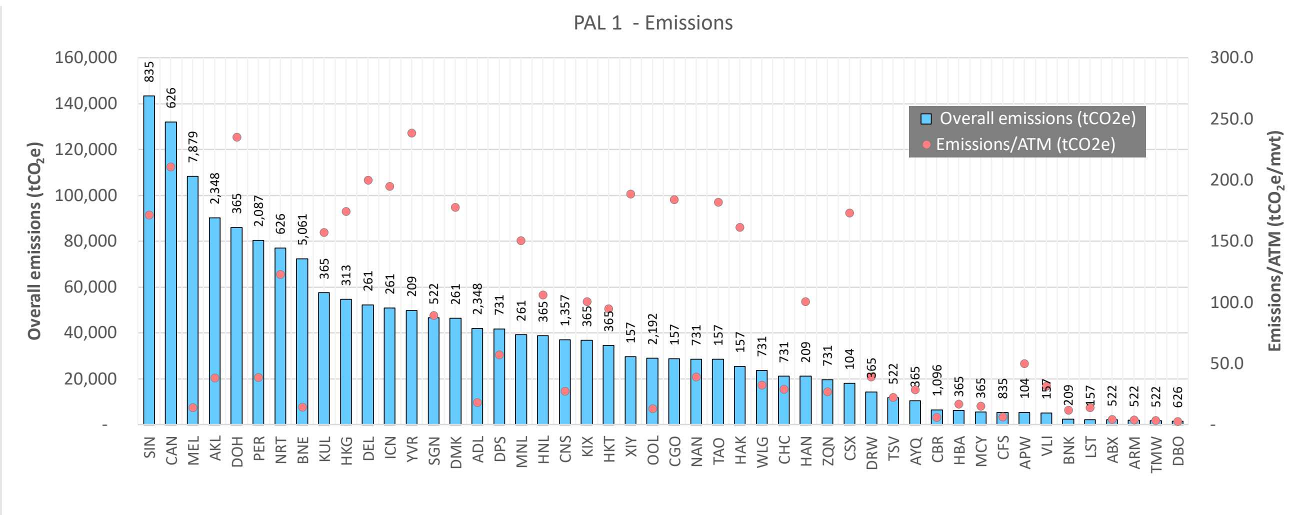

Figure 8.2 2033 full flight departure emissions – total tCO_2e and tCO_2e per air traffic movement

In 2055, all flights departing from WSI to all 86 destination airports across its anticipated route network are projected to emit approximately 8.65 Mt CO_2e an increase of around 6.9 Mt CO_2e when compared to 2033 levels. Short haul flights on routes of less than 500 nm (915 km) accounted for 38 per cent of total flight activity, an 11 per cent drop, representing around 6 per cent of total emissions of CO_{2e}, down 7 per cent.

Long haul flights represent a significantly higher share of total movements at 23 per cent, accounting for 63 per cent of the total CO_2e emitted (refer to Figure 8.1). Total emissions of CO_2e from long haul flights increased by 4.8 Mt CO_2e to 5.5 Mt CO_2e.

Other segments between 500 nm (926 km) and 4,000 nm (7,408 km) remained stable accounting for 41 per cent of all traffic movements in 2033 reducing slightly down to 39 per cent of traffic movements in 2055, representing around 31 per cent of total CO_2e emissions at 2.6 Mt CO_2e.

Figure 8.3 shows the full flight emissions of CO_2e estimated for all flights in the 2055 schedule serving 86 routes across the WSI network. The WSI route network in 2055 includes an additional 38 routes compared to 2033 most of which are for international RPT services except for 8 routes that operate to new intrastate (2) and Australian domestic (6) destinations.

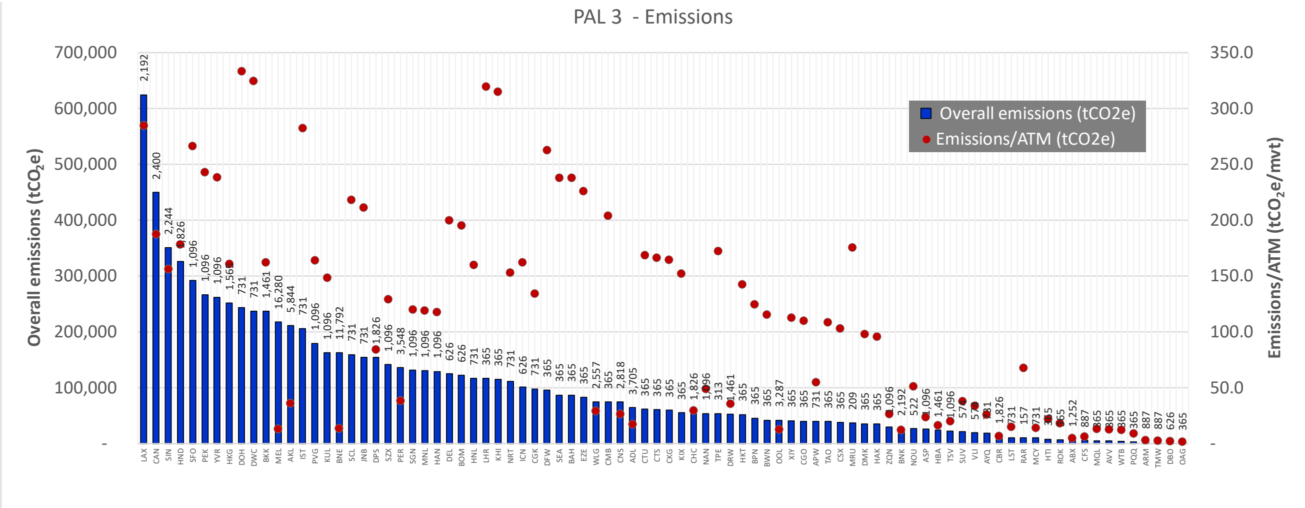

Figure 8.3 2055 full flight departure emissions – total tCO_2e and tCO_2e per air traffic movement

The top 5 carbon emitting routes were all international RPT services to long haul destinations over 4,000 nm (7,408 km). Approximately 9,757 departures are projected to operate these routes (around 9 per cent of total departure movements in the schedule) emitting around 2.0 Mt CO_2e. This represents around 24 per cent of total flight departure emissions in 2055 at an average carbon intensity of 209 tCO_2e/ATM.

Table 8.4 shows the tonnes of CO_2e emitted by aircraft operating services on the top 5 carbon emitting routes across the expected WSI network in 2033 and 2055. The significant increase in total emissions of CO_2 is attributed to a combination of projected route distance and service frequency for these mostly long-haul destinations. These long haul routes tend to be operated by large, WBJ aircraft that use considerably more fuel and emit greater amount of CO_2e than smaller NBJ and turbo-props operating RPT services to shorter haul domestic and international (trans-Tasman) destinations.

Table 8.4 Top 5 carbon emitting flight routes in 2033 and in 2055

WSI	2033 Mt CO_2e	%	ATMs	tCO_2e/ATM		2055 Mt CO_2e	%	ATMs	tCO_2e/ATM
Projected full flight emissions for Top 5 route at WSI in 2033 and in 2055									
SIN	0.14	8.08	835	171.7	LAX	0.62	7.24	2,192	284.8
CAN	0.13	7.45	626	210.9	CAN	0.45	5.22	2,400	187.3
MEL	0.11	6.11	7,879	13.7	SIN	0.35	4.07	2,244	156.3
AKL	0.09	5.09	2,348	38.4	HND	0.33	3.78	1,826	178.3
DOH	0.09	4.85	365	235.3	SFO	0.29	3.39	1,096	266.4
Total	**0.56** (rounded)	**31.6**	**12,053**	**46.44**		**2.04** (rounded)	**23.7**	**9,757**	**209.2**

8.3.4 Single aircraft movement emissions

The emissions of CO_2e have been calculated for 10 of the most common aircraft types (refer to Table 6.6) anticipated to operate at WSI in 2033 and in 2055.

In 2033, the Boeing B737-800 aircraft was projected to operate the most flights accounting for around 27 per cent of total daily movements. The Boeing B737-800 flights typically operate on short-haul domestic routes (e.g., Brisbane and Melbourne) and some longer intrastate (i.e., Ballina) and shorter haul international routes (i.e., trans-Tasman). In total the aircraft accounts for the highest proportion of CO_2e below 10,000 ft (3,048 m) with almost 31,087 tonnes. The Boeing B737-800 accounted for around 24 per cent of WSI's total CO_2e emissions below 10,000 ft (3,048 m).

The Boeing B7M8 (MAX) was projected to operate around 20 per cent of flights in 2055. Total emissions of CO_2e are more than for any other aircraft in 2055, around 52,439 tonnes or 12 per cent of total CO_2e emissions below 10,000 ft (3,048 m). Compared to the Boeing B737-800, the Boeing B7M8 (MAX) is around 22 per cent more fuel efficient per movement below 10,000 ft (3,048 m), saving approximately 0.62 tCO_2e. Figure 8.4 shows a breakdown of CO_2e emissions for a Boeing B738 and B7M8 below 10,000 ft for each phase of flight in the LTO cycle.

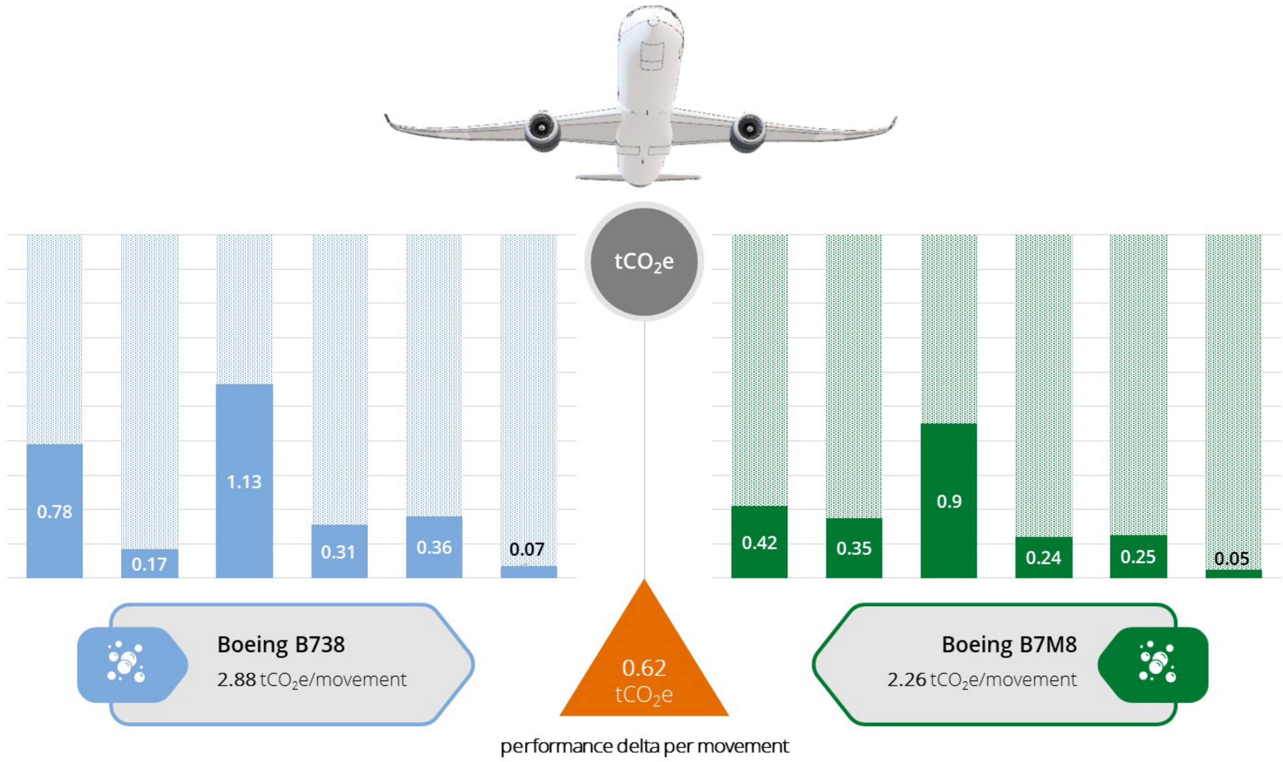

Figure 8.4 LTO cycle emissions profile for a single Boeing B738 and a B7M8 movement

Table 8.5 provides a breakdown of CO_2e emissions for each phase of flight in the extended C-D cycle modelled below 10,000 ft (3,048 m). The emissions of CO_2e are apportioned to each phase of flight and summed to show an aggregated profile of the CO_2e emitted on a single (one) movement basis – i.e., an arrival and a departure.

Table 8.5 Single movement CO_2e emissions for selected aircraft types below 10,000 ft (3,048 m)

Flight phase Aircraft type	Take-off roll tCO_2e	Initial climb tCO_2e	Extended climb tCO_2e	Extended descent tCO_2e	Final approach tCO_2e	Landing roll tCO_2e	Total **tCO_2e**
Projected commercial aviation emissions in 2033 and in 2055							
A221	0.30	0.54	1.01	0.40	0.36	0.05	**2.65**
A322	0.44	0.84	1.41	0.13	0.44	0.07	**3.33**
A21N	0.54	0.95	1.62	0.23	0.46	0.08	**3.89**
B738	0.40	0.57	1.16	0.32	0.37	0.07	**2.88**
B7M8	0.29	0.50	0.92	0.24	0.26	0.05	**2.26**
A333	1.01	0.97	0.54	0.90	0.58	0.06	**4.06**
A359	1.02	0.87	0.49	0.95	0.62	0.09	**4.04**
B77W	1.77		1.81	5.08	0.89	1.42	**0.12**
B789	1.16	1.58	2.59	0.39	0.66	0.06	**6.43**
B74N	1.61	3.19	4.78	1.91	1.70	0.22	**13.42**

8.4 Australian context

8.4.1 National

In Australia, the DCCEEW is responsible for the reporting of GHG emissions. This includes all aspects of the national inventory systems, including activity data coordination, the estimation of emissions, quality control, the preparation of reports and their submission to the UNFCCC on behalf of the Australian Government.

The transport sector is one of the strongest drivers of Australia's GHG emissions. Except for observed decreases caused by the recent COVID-19 pandemic, GHG emissions from the transport sector have trended consistently upward over time. This is mainly attributable to population and economic growth. This upward trend has been partially offset by improved efficiency in ground transportation modes (road and rail) and the progressive market uptake of electric vehicles.

Transport emissions are produced from the combustion of fuels (like petrol, diesel, kerosene (Jet A-1/Avgas) and bunker fuel) for road, rail, domestic aviation and domestic shipping, off-road recreational vehicles and gas pipeline transport. Transport is currently the second largest source of emissions in Australia, responsible for approximately 20 per cent of the national carbon budget in 2019. Emissions from the transport sector were reported at 100.3 Mt CO_2e by the Australian Government, around 22 per cent above 2005 levels of 82 Mt CO_2e (DCCEEW 2021). Approximately 85 per cent of emissions from the transport sector in 2019, around 85 Mt CO_2e, were attributed to road transport (buses, cars and light-duty and heavy vehicles).

Emissions from the transport sector are expected to continue increasing until 2030. This is largely driven by the forecast increase in domestic aviation and heavy vehicle, passenger and freight emissions. Population and economic growth continue to increase demand for freight which is responsible for the upward trend in emissions from heavy vehicles. Improvements in vehicle efficiency and greater uptake of electric vehicles are projected to reduce car and light commercial vehicles' share of transport emissions between 2025 and 2030.

Opportunities to reduce transport emissions may be facilitated through a continued mode shift to public and active transport alternatives, and an accelerated transition towards electric cars, bikes, trucks and buses. With strong policies and a new, coherent fiscal stimulus from the Australian Government on fuel efficiency, fuel quality and low emissions vehicles, current technologies could lead to a significant reduction in emissions from road-based transport. Decarbonisation of domestic aviation and shipping will be more difficult. These hard to abate sectors are reliant on greater use of alternative, sustainable fuel technologies and new generation engine propulsion systems. The maturity of these technologies continues to evolve through ongoing research and development. The availability and commercialisation of these technologies at scale and competitive prices is anticipated not to be widely available until around 2035 and beyond.

According to Australia's National Greenhouse Accounts (DCCEEW 2022), in 2021, GHG emissions from transport had decreased by around 10 per cent to 90.2 Mt CO_2e from 100.3 Mt CO_2e reported in June 2019. The primary drivers of this decrease were attributed to the progressive uptake of electric vehicles being powered by an increased share of renewable energy in the generation mix of Australia's National Electricity Market. In the 5 years between 2015–2019 consumption levels of aviation turbine fuel experienced a 17 per cent increase from 7,739 to 9,057 megalitres.

Table 8.6 shows the CO_2e emissions reported by the Australian Government for all sectors, including the transport sector. As a subset of the transport sector, CO_2e emissions for Australia's commercial aviation sector broken down by domestic and international activity is also shown.

Table 8.6 Historic and projected total economy wide GHG emissions for Australia

Australia	2019		2033		2055	
	Mt CO_2e	%	Mt CO_2e	%	Mt CO_2e	%
Reported economy wide emissions in 2019 and projected commercial aviation emissions in 2033 and in 2055						
All sectors	**529.4**	**100**	**340.1**	**100**	**175.8**	**100**
Transport	100.4	19	101.3	30	81	46
Commercial aviation activities as a subset of transport emissions						
Domestic	8.3	35	11.2	37	18.6	34
International	15.4	65	18.8	63	36.1	66
Total	**23.7**	**100**	**30**	**100**	**54.7**	**100**

Reflecting the fuel consumption rates in Australia's latest SAP published in October 2022, Managing the Carbon Footprint of Australian Aviation (DITRDCA 2022), emissions from commercial aviation were reported to be 23.7 Mt CO_2e in 2019, based on 9,057 megalitres of fuel use.

Broken down, in 2019, domestic aviation activity in Australia emitted around 8.3 Mt CO_2e (35 per cent) of Australia's total aviation emissions from a total of 1,271,258 domestic flights (including regional). Domestic aviation activity represented 86 per cent of all RPT services operating at selected Australian airports. The carbon intensity of domestic RPT services is likely to be higher than international RPT services due to the higher average fleet age (17.1 years) of domestic aircraft versus international aircraft (10.6 years) operating in the commercial fleet at that time.

Assuming growth in Australia's domestic and international aviation markets followed the 2.2 per cent (domestic) and 3 per cent (international) annual increases projected by the Australian Government Department of Environment and Energy (now the DCCEEW), Australia's commercial aviation emissions could be as high as 33.9 Mt CO_2e in 2033, up 43 per cent from the 23.7 Mt CO_2e emitted in 2019. In 2055, a more than doubling of CO_2e emissions is projected from Australian aviation activity.

Section 8.4.3 will compare the WSI projected emissions against this national background and the NSW background in the following section.

8.4.2 New South Wales

The NSW Government is committed to action to reduce GHG emissions that is broadly consistent with the level of effort to achieve Australia's short- and long-term emissions savings targets.

Between 2005 and 2019, GHG emissions in NSW have decreased by 17 per cent from around 165 Mt CO_2e to around 136.6 Mt CO_2e, excluding the land sector. The main sources were from:

- stationary energy for electricity generation emitted around 52 Mt CO_2e (accounting for 37 per cent of total NSW emissions)
- transport emitted around 28 Mt CO_2e (accounting for around 20 per cent of total NSW emissions).

NSW transport sector emissions in 2019 were reported to be around 28 Mt CO_2e, up by 16 per cent on 2005 levels of 24 Mt CO_2e. In 2019, around 24.3 Mt CO_2e (88 per cent) of NSW's transport emissions were from road-based transport, split between cars and light commercial vehicles accounting for 15.8 Mt CO_2e (65 per cent) and heavy-duty vehicles 5.6 Mt CO_2e (23 per cent). Domestic aviation emissions (intrastate and Canberra) were the next largest source of transport emissions with around 2.4 Mt CO_2e (9 per cent), with smaller contributions from other modes of transport. As a proportion to total NSW emissions, domestic aviation activity (i.e., intrastate activity within NSW only) was responsible for around 2.4 Mt CO_2e (1.7 per cent).

An upward trend in emissions from the transport sector is expected to continue alongside population and economic growth, particularly for intrastate aviation and heavy-vehicle road transport. Under current NSW Government policies, emissions reductions from the uptake of light duty electric vehicles and the electrification of buses are anticipated to help offset overall increases in transport emissions which according to NSW Government projections will peak around 2025/2026 at 29.7 Mt CO_2e before falling to 28.7 Mt CO_2e at the end of the decade.

Table 8.7 provides a breakdown of CO_2e emissions reported for all sectors, including domestic aviation in 2019. Projections of CO_2e emissions are also provided for 2033 and 2055. These adopt the 2.2 per cent annual growth factor set by the Australian Government for domestic aviation activity from the 2017 SAP (DIRD 2017).

Table 8.7 Historic and projected total economy wide GHG emissions for NSW

NSW	2019		2033		2055	
	Mt CO_2e	%	Mt CO_2e	%	Mt CO_2e	%
Reported economy wide emissions in 2019 and projected commercial aviation emissions in 2033 and in 2055						
All sectors (total)	136.6	100	55.9	100	25.6	100
Transport	27.6	20	19.9	36	5.7	22
Commercial aviation activities as a subset of transport emissions						
NSW aviation	2.4	1.7	1.8	3.2	2.8	11

In 2033 and in line with current NSW Government policy commitments, total GHG emissions are projected to fall to around 55.91 Mt CO_2e. This represents a 41 per cent reduction from 2019 levels. The source of the reductions is largely attributed to an increased share of renewable energy supplying the NSW electricity grid. Transport sector emissions are expected to become the largest source of NSW emissions by 2055, accounting for 22 per cent of total GHG emissions or 5.67 Mt CO_2e.

In following the same national growth projection, NSW aviation emissions from commercial aviation activity within the NSW only could be as high as 3.2 Mt CO_2e in 2033 if it continues the same trajectory as 2019. That said, emissions from intrastate RPT services (including those to Canberra) are projected to fall to around 1.8 Mt CO_2e largely due to more fuel-efficient aircraft entering the fleet mix like the Airbus A220-100 and A32N and Boeing B7M8.

8.4.3 WSI

Under the UNFCCC, domestic and international aviation are treated separately. Domestic aviation emissions are calculated as part of Australia's Paris Agreement target while international aviation emissions are dealt with separately as part of Australia's involvement in ICAO. To avoid the risk of double counting, only the flights departing from WSI have been modelled in the full flight assessment to calculate estimated emissions of CO_2e as all origin airports across the WSI route network would account for their flight departure emissions. These CO_2e emissions have been projected in 2033 and in 2055 and then compared to economy wide emissions projections by the Australian and NSW Governments in these years. The economy wide emissions account for emissions from several sectors including agriculture, energy, industrial processes, resources, transport (inclusive of commercial aviation) and waste.

These comparisons have been used to determine the potential significant impact of WSI's domestic flight departure emissions on the Australian and NSW Government's ability to comply with the Paris Agreement and transition to net zero economies by 2050. International flight departure emissions from WSI are excluded from these comparisons but are presented to provide a total full flight emissions footprint for all flights departing WSI to each destination airport across WSI's anticipated route networks in 2033 and 2055.

Table 8.8 shows the full flight CO_2e emissions projected in 2033 and in 2055 for WSI. The aircraft tailpipe CO_{2e} emissions projections are split by NSW (domestic aviation activity within NSW only), Australian (domestic exclusive of NSW activity) and international aviation activity.

Table 8.8 WSI full flight CO_2e emissions projections in 2033 and 2055 (departures only)

WSI	2033				2055			
	Mt CO_2e	%	ATMs	tCO_2e/ATM	Mt CO_2e	%	ATMs	tCO_2e/ATM
Projected full flight emissions (departures from WSI only) in 2033 and in 2055								
NSW (intrastate)	0.02	1	3,235	4.9	0.05	1	7,462	6.8
Australia (domestic excl. NSW)	0.43	25	24,159	17.6	0.9	10	52,387	17.3
International	1.3	74	13,201	100.9	7.7	89	53,900	142.2
Total	**1.75** (rounded)	**100**	**40,595**	**43.7**	**8.65** (rounded)	**100**	**113,749**	**75.6**

When comparing WSI's projected aircraft tailpipe emissions of CO_2e (full flight departures only) to the total economy wide emissions projections of the Australian and NSW Governments, the following observations are made:

- **2033:** the project's domestic flight departure emissions of CO_2e would represent 0.13 per cent for Australia's total projected economy wide emissions which is low whereas the project's intrastate flight departure emissions of CO_2e would represent around 0.04 per cent of NSW's total economy wide emissions, which is extremely low resulting in very minor adverse impacts to Australian and NSW Government's decarbonisation plans and transition to net zero carbon economies by 2050.
- **2055:** the project's domestic flight departure emissions of CO_2e are projected to increase to 0.95 Mt CO_2e and would represent 0.5 per cent of Australia's total projected emissions which is moderately low whereas the project's intrastate flight departure emissions of CO_2e would represent around 0.2 per cent of NSW's total projected economy wide emissions, remaining low despite the significant increase in air traffic growth and increase in the number of domestic destinations being served.

The emissions of CO_2e attributed to single runway operations at WSI from aircraft departing to destination airports across WSI's anticipated 2033 and 2055 route networks is not considered to result in significant impacts or inhibit the achievement of net zero economy wide targets set by the Australian Government or NSW Government for 2050. It is expected that these emissions of CO_2e would reduce over these time horizons as more fuel efficient, next-generation aircraft enter service and operate within the fleets of airlines and freight companies serving WSI, improvements are made to air navigation and air traffic management infrastructure and operations and the anticipated availability and use of SAF progressively increases. Uptake of SAF, the emergence of new aircraft and engine propulsion systems along with the continual modernisation and optimisation of airspace across the Sydney Basin will all contribute to the progressive reduction of emissions. The exact extent of these reductions in future years remains difficult to determine because the actual mix of new generation aircraft and the availability, commercialisation and scalability of SAF is uncertain.

All anthropogenic (human-induced) activity produces GHG emissions. For this assessment, the CO_2e emissions produced by the project have been set in the context of projected CO_2e emissions from domestic commercial aviation activity in Australia and NSW. This is aligned to the commitments made by the Australian Government as a party to the UNFCCC and Paris Agreement, which include Australia's 2030 emissions reduction targets and an economy wide 2050 trajectory to net zero emissions.

Projections of CO_2e emissions have been obtained from the Australian National Greenhouse Accounts (DCCEEW 2022), a review of Australia's NIRs (DCCEEW) submitted to the UNFCCC each year and growth rates forecast by the Australian Government for commercial aviation activity in the 2017 SAP (DIRD 2017). This has been supplemented by historic and projected CO_2e emissions obtained from the NSW EPA under the SOE program.

Direct impacts associated with the project have been accounted for in the total GHG emissions for NSW and Australia. GHG emissions projections for the project in 2033 and extrapolations in 2055 are not expected to make any significant contributions to Australian and NSW economy wide GHG emissions.

Table 8.9 summarises historic and projected emissions of CO_2e by the Australian and NSW Governments, together with WSI's aircraft tailpipe CO_2e emissions projections in 2033 and in 2055. The CO_2e emission projections provided in 2033 and in 2055 have adopted the 2.2 per cent and 3 per cent annual growth factors set by the Australian Government for domestic and international aviation activity from the 2017 SAP (DIRD 2017).

Table 8.9 Comparing projected aircraft tailpipe CO_2e emissions for WSI to Australian and NSW Government economy-wide emissions (historical and projected) in 2033 and in 2055

Parameter	2019 (Mt CO_2e)	2033 (Mt CO_2e)	2055 (Mt CO_2e)
Australia total (economy wide) **emissions –** DISER 2021 historic and future projections made by Airbiz			
All sectors	529.3	340.1	175.8
Transport	100.4	101.3	80.97
% contribution of transport	19	30	46
% contribution of aviation	5	9	31
Australia commercial aviation emissions (as a proportion of Australia's economy-wide emissions)			
Domestic	8.3	16.5	18.6
International	15.4	17.4	36.1
Total	23.7	33.9	54.7
NSW total (economy wide) **emissions –** NSW EPA State of Environment 2019 historic and future projections made by Airbiz			
All sectors	136.6	55.9	25.6
Transport	27.6	19.9	5.7

Parameter	2019 (Mt CO_2e)	2033 (Mt CO_2e)	2055 (Mt CO_2e)
NSW domestic aviation emissions (as a proportion of NSW's economy wide emissions)			
Aviation	2.4	1.8	2.8
% contribution of aviation	1.7	3.2	10.8
WSI			
Full flight emissions (all domestic flight departures)		0.45	0.95
% contribution of Australia total (economy wide) (all domestic full flight departure emissions only)		0.13	0.5
Full flight emissions (NSW intrastate aviation only)		0.02	0.05
% contribution of NSW total (economy wide) (intrastate full flight departure emissions only)		0.04	0.2
Full flight departure emissions (domestic and international)		1.75	8.65

*Mt CO_2e – million tonnes of carbon dioxide equivalents

8.5 Climate risk

The Sydney Basin is in a temperature climate zone. The climate is characterised by mild winters and warm, humid summers. The average annual temperature is around 18 degrees Celsius with year-round precipitation (rainfall) of normally around 1,000 millimetres.

The landscape typology is varied, ranging from coastal areas along the Tasman Sea to the east, to the eucalypt forests, sandstone plateaux and deep gorges of the GBMA in the Great Dividing Range to the west, to the Illawarra Escarpment to the south. The lower-lying parts of the Sydney Basin, especially around the Airport Site are characterised by low, undulating hills and tributaries of the Hawkesbury-Nepean River Catchment.

With an estimated resident population of more than 5.2 million people (ABS 2022), the Sydney Basin is home to almost one in 5 Australians and is a hub of diverse anthropogenic activities, including civil and defence aviation. The Sydney Basin contains many national parks which have cultural and world heritage significance.

The climate of the Sydney Basin is already changing and subject to more extreme weather events most notably the widespread bushfires of 2019–2020, increased coastal erosion from more frequent east coast low storm systems and the severe flood events of 2021-2022. The long-term nature of the predicted effects of climate change makes it difficult to pinpoint potential impacts within relatively short duration and near term events such as those associated with the early years of single runway operations at WSI in 2033 and an interim year of single runway operations at WSI in 2040. Therefore, the focus of the climate assessment was on the potential risks to single runway operations as they're expected to near capacity in around 2055.

According to the climate change projections from the NSW Government (obtained from the NSW and ACT Regional Climate Modelling project), increased temperatures are projected to be on average about 0.7 degrees Celsius warmer in the near future (by 2030), increasing to about 1.9 degrees Celsius in the far future (by 2070). Near the Airport Site, the number of high temperature days (above 35 degrees Celsius) is projected to increase along with the duration and intensity of fire weather, with seasonal rainfall patterns to change (i.e., increase in summer and autumn and decrease in winter and spring). The greatest increase in the number of hot days (maximum temperature above 35 degrees Celsius) is projected for Western Sydney with an additional 5 to 10 days by 2030, increasing to over 10 to 20 additional hot days per year by 2070. Projected changes to the forest fire danger index (bushfire risk) anticipate average fire weather to increase in spring by 2030 and increase in spring and summer by 2070.

For flight operations at WSI, aircraft performance during take-off is dependent on many variables. Airport elevation and the outside air temperature are primary determinants of an aircraft's MTOW. Another key factor is the local atmospheric conditions – temperature and humidity, wind speed and direction and the presence of turbulence.

As a rule, not all these factors are known at the exact time of departure and vary along the length of a runway. The highly variable nature of weather conditions adds to the uncertainty of aircraft take-off performance.

The take-off distance and the initial rate of climb of a departing aircraft is determined by the MTOW and engine power (thrust) setting. An aircraft's engine power (thrust) during take-off and the initial climb phase of flight depends on the speed, weight, climb rate and configuration (flap settings and undercarriage position) of the aircraft and the atmospheric state – the 'weather'. The 3 basic elements of weather – temperature (hot and cold), wind (speed and direction) and moisture (or humidity) create conditions which can significantly affect aircraft operations, flight schedules and pilot decisions. Weather can reduce visibility (low cloud, fog, rain) around an airport, cause turbulence (thunderstorms, lightning) from rapidly rising/falling air currents and reduce aircraft performance, especially the time and distance to take-off and climb, fuel burn, payloads and safety margins.

Aircraft weight restrictions are imposed when the temperature threshold above which the aircraft cannot take-off at its MTOW due to the available runway length is reached. In hot weather these restrictions could result in the offloading of passengers/baggage and cargo so an aircraft can depart within its safe MTOW threshold. On the most affected aircraft, likely to be WBJ flying to long-haul destinations, weight restrictions and adapted operating procedures could adversely impact flight economics. In warmer, less dense air, aircraft must increase engine power (thrust) to travel down the runway to produce enough lift to take-off. This in turn increases fuel consumption, operating costs and CO_2e emissions.

WSI and the sector must also consider the physical impacts of a warming climate, including more extreme weather events, which could affect airport infrastructure and operations as well as the airport's key destinations, and cause significant harm to the global economy. Climate-related risks present varying levels of risk to WSI and the aviation sector more generally. Climate hazard impacts are likely to directly affect WSI (i.e., damages result from direct contact with the hazard) such as damage to airport infrastructure or flight disruptions (i.e., delays and cancellations).

Impacts have the potential to affect:

- functionality of the airport, i.e., the ability to transport freight and passengers
- performance, i.e., customer experience at the airport and the efficiency of processes, particularly the on-time performance of aircraft and flight schedules
- operations, i.e., aircraft on the ground and in the air, along with ground handling and servicing, and aeronautical safety procedures.

Many airlines and airports, including those in Australia use scenario analysis as a tool to examine pathways for emerging trends and to determine climate risks likely to be encountered to help better understand the resilience of their built assets (i.e., buildings and infrastructure) and operations.

Scenario analysis inherently relies on assumptions of economic and technological shifts, commodity dependencies, meteorology forecasts and climate science. The use of these projections makes it difficult to predict with certainty which scenario might eventuate and therefore its outcomes are not considered definitive. Climate scenario analysis is normally used as a key control to identify and manage climate change risk over time. The scenarios are not intended to predict the future, but rather explore different possible climate futures to better understand and manage the resilience of WSI (especially flight activity) operating under these scenarios.

Three scenarios based on Representative Concentration Pathways (RCPs) published in the IPCC's Sixth Assessment Report (AR6) have been used for this purpose as part of a qualitative analysis. Figure 8.5 shows these 3 scenarios as well as a fourth scenario, "delayed action" developed by the Network of Central Banks and Supervisors for Greening the Financial System[31] (NGFS 2022). This fourth scenario allows potential climate risks to be examined along a delayed transition from the world's current decarbonisation pathway to a pathway consistent with the long-term climate goals of the Paris Agreement.

[31] Network for Greening the Financial System, September 2022, NGFS Climate Scenarios for central banks and supervisors

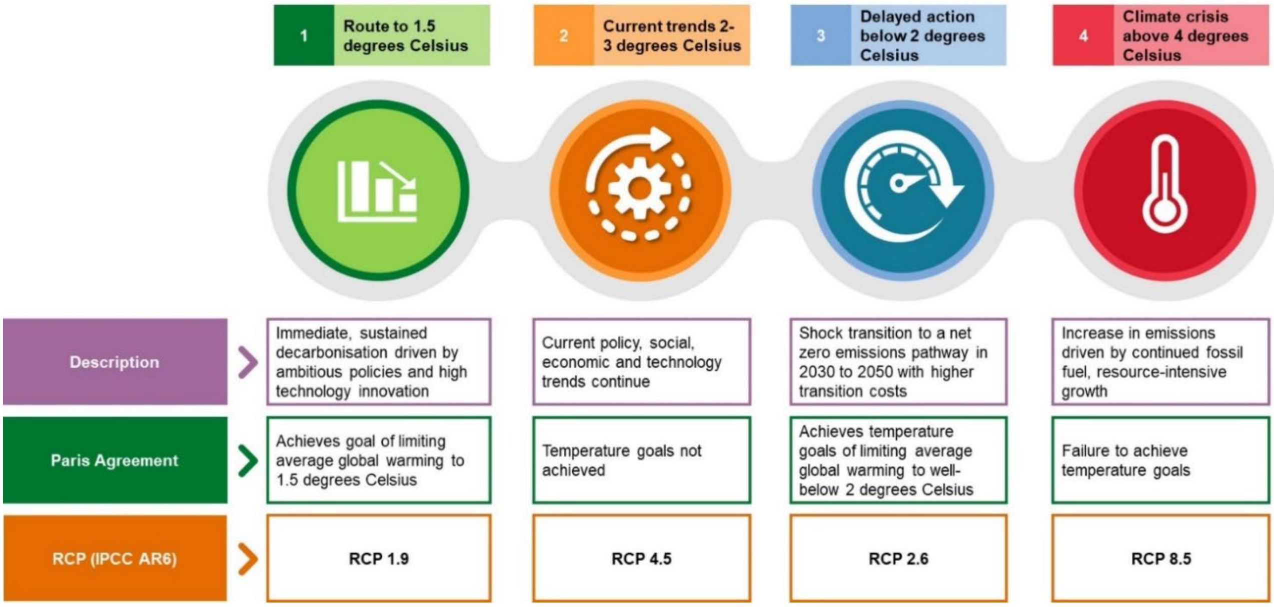

Figure 8.5 Scenarios for WSI climate resilience

These scenarios assume various degrees of average global temperature rise by 2100 and include social, technological, economic and political developments considered plausible under each warming trajectory. Under each scenario the following potential impacts have been identified to understand the possible impact to flight operations at WSI:

1. **Route to 1.5 degrees Celsius** – under this climate change scenario, strong policy intervention will be present, which may include a global price on carbon, with government policies supporting a global transition to a low carbon economy. It also anticipates strong investment in low emission aircraft technologies as economic growth occurs in line with net zero emissions. For WSI, this transition path would see more efficient aircraft flying to WSI fuelled by SAF, hydrogen or electricity, with airport infrastructure in place to meet these future energy demands.
2. **Current trends 2–3 degrees Celsius** – under this climate change scenario, steady levels of emissions reduction are expected in line with current policy, growth and technological trends. Demand for renewables is expected to increase but at a slower pace along with the maturation of alternative aircraft propulsion systems and SAF production capacity. Business travel demand is expected to flatten with a gradual upward surge in carbon pricing. For WSI, physical impacts are anticipated to be higher under this scenario than in scenarios one and 3, with changes possibly required to operational procedures for greater resilience to more frequent and intense extreme weather events. Improvements in aircraft efficiency are anticipated to continue at around 1.5 to 2 per cent per year, driven by operator demand for greater levels of fuel economy. Low or no emissions SAF would power some aircraft flying to WSI (likely to be inbound flights only under offshore offtake agreements brokered by airlines and SAF suppliers), with airport infrastructure in place to meet these changing energy demands.
3. **Delayed action below 2 degrees Celsius** – under this climate change scenario, rapid economy wide emissions reduction is expected to be led by the market in response to new government policy and fiscal stimulus. Improvements to air traffic management infrastructure and services, operations and fuel economy are expected to increase through greater collaborative efforts between the airlines, airports, Airservices and the DITRDCA. For WSI, physical impacts are anticipated to be lower under this scenario, changes may still be required to operational procedures to adapt to more frequent extreme weather events. Improvements in aircraft efficiency are anticipated, driven by consumer demand for lower emissions travel and airline focus on fuel economy. Low or no emissions SAF would power more aircraft (certainly inbound aircraft from international markets), with airport infrastructure in place to meet these changing energy demands (subject to the availability of price competitive SAF locally).
4. **Climate crisis above 4 degrees Celsius** – under this climate change scenario, global emissions continue at current rates. The worst physical impacts of climate change are expected to be optimize as temperatures rise, and extreme weather events increase. With more frequent extreme weather events under this scenario, WSI's operations could be disrupted with damage to infrastructure in and around the Airport Site from heavy downpours, inundation by floodwaters, more extreme heat days over 35 degrees Celsius impacting flight performance (especially for outbound aircraft) and longer periods of dryness extending the potential of fire weather.

Climate-related risks and adaptation opportunities will be important ongoing considerations for WSI's strategic planning and operational resilience. The measures developed in response to climate-related risks prioritise operational solutions.

Three-time horizons have been used to qualitatively assess the potential climate-related risks for WSI as depicted in Figure 8.6.

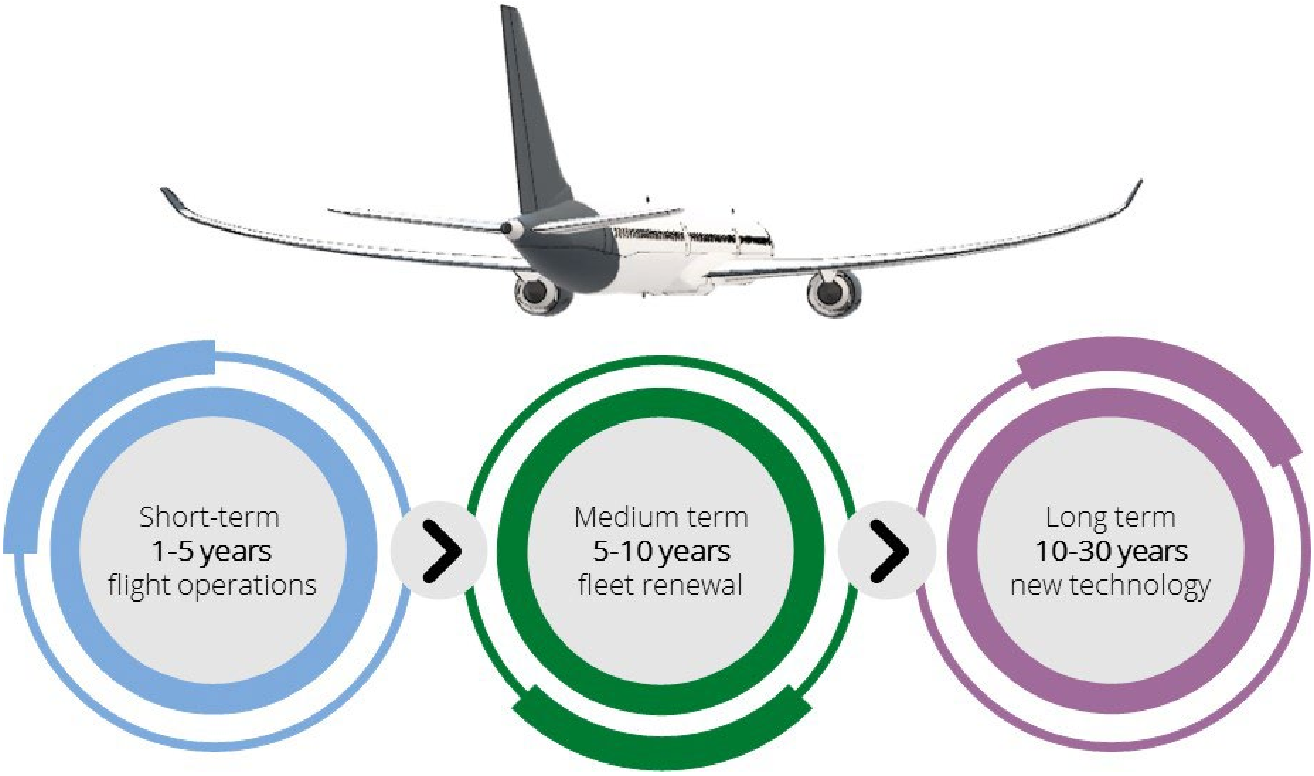

Figure 8.6 WSI climate-related risks and opportunities

Climate change also presents opportunities for the airlines, air freight operators, Airservices Australia and WSA Co. These include:

- lowering operating costs by reducing fuel consumption during flight through investment in more fuel efficient, next generation aircraft that emit less CO_2
- optimizing flight efficiency through airspace that is configured to allow users to fly more fuel-efficient trajectories and introducing specific operational measures that reduce track miles and flight times and fuel consumption (such as measures that reduce holding/sequencing times), and help to optimize fuel burn of aircraft operations in all phases of flight (for example through better aircraft weight management, or optimizing fuel management practices) all of which reduce associated emissions of CO_2e
- playing a role in the development of a local SAF market in Australia that can produce the quantities required to increase its overall share in the fuel mix to above 30 per cent by 2035 (subject to the establishment and maturation of local SAF industry and market to support outbound demand by Australian and international airlines and freight operators)
- supporting airline partners to equip aircraft with latest technology for all-weather operations
- supporting airline partners to reduce their emissions through provision of electrification and low-emission fuels infrastructure (i.e., SAF).

Table 8.10 shows the main climate-related risks to WSI and future flight operations, along with a selection of future control measures to manage and adapt to a changing climate.

Table 8.10 WSI climate-related risk drivers

Climate risk	Impact on WSI flight paths	Risk timeframe	Future controls
Short term 1-5 years	**Medium term 5-10 years**	**Long term 10-30 years**	
Physical risks			
Increased frequency and intensity of storm and heavy rainfall events	Damage to infrastructure, business interruption and flight disruptions (delays and cancellations) due to flooding from heavy downpours and inundation of assets critical to WSI operations (runways/taxiways, lighting, navigational aids)	Short term Medium term Long term	Airfield design and infrastructure to be flood resilient based on climate change modelling Airfield to be equipped with suitably sized, efficient stormwater drainage systems
Variable wind patterns, high wind speed bursts and changes to prevailing wind direction	Changes to flight times and routes affecting airport capacity and runway utilisation	Medium term Long term	Annual review of wind direction data to identify emerging changes that would impact fuel consumption and associated emissions
Rising mean temperatures	Increase in operating costs (fuel, airframe parts and systems) as aircraft are required to fly at suboptimum performance and profiles or need more engine power (thrust) to take-off and climb in an increased temperature and humidity range Possible imposition of payload restrictions to carry extra fuel (passengers and cargo) impacting the commercial viability of some routes	Medium term Long term	Factoring future requirements into long-term aircraft asset management and replacement plans, especially engine performance
Bushfires	Increase in frequency, intensity and severity of bushfires (fire generated thunderstorms and thick smoke plumes) across longer fire seasons resulting in flight delays and cancellations, route changes due to fire/smoke risks	Short term Medium term Long term	Better integration of weather forecasts, fire alerts and contingency plans

In the years to 2040, GHG emissions from aircraft engine use along WSI's flight paths and route network are unlikely to make material difference in the physical risk of future climate change projections made by the Australian Government, as historic GHG emissions have already been locked in global warning over this timeframe. Beyond this date to 2055, WSI's GHG emissions would marginally contribute to potential climate change but not at a level expected to inhibit Australia's commitment to emissions reduction targets or a net zero emissions transition by 2050. Nonetheless, this assessment has not factored the benefits associated with CO_2e emissions savings that are expected to result from improvements in air traffic management infrastructure and services, new aircraft technology and fuel measures (SAF).

Chapter 9 Facilitated impacts

It is anticipated that the facilitated airspace changes will not significantly impact the climate of the Sydney Basin or total GHG emissions levels as they will occur within areas already subject to and expected to continue to be subject to routine flight paths by aircraft from Sydney (Kingsford Smith) Airport, Bankstown and Camden Airports, and RAAF Base Richmond.

Most adjustments required to existing flight paths do not result in any discernible extension or reduction in track distance lengths (i.e., greater than 1 nm or 1.852 km) that would impact flight times to the extent that material changes in aircraft tailpipe CO_2e emissions from WSI could be determined in aircraft fuel consumption (burn rates) and associated CO_2e emissions.

For those flight paths where the changes facilitated by WSI extend or shorten by more than 1 nm (1.852 km) an assessment of GHG emissions for selected representative aircraft is provided in Technical paper 13.

Chapter 10 Cumulative impacts

Cumulative impacts have the potential to occur when impacts from a project interact or overlap with impacts from other projects at a specific location or over different periods of time. These impacts can potentially result in a larger overall effect (positive or negative) on the environment and GHG emissions budget[32] in Australia and in NSW.

Recent and proposed changes in planning, such as that occurring within the broader Western Sydney Aerotropolis precinct, will produce GHG emissions, where development, infrastructure, land use, transportation and associated activity will intensify over time as the Aerotropolis transitions into a city. Potential cumulative impacts on GHG emissions from WSI's preliminary airspace design and other planned and potential projects in the locality include:

- incremental increases in transportation activity on ground-based road and rail networks with the potential to impact travel times due to congestion, customer experience at the airport and operational efficiency, i.e., the ability to transport freight and passengers on-time
- alterations to air quality in Western Sydney
- increases in the projected GHG emissions budgets of Australia and NSW
- changes to the climate of the Sydney Basin with the potential to impact biodiversity.

All anthropogenic (human-induced) activity and development (existing and new) produce GHG emissions. For this assessment, the tailpipe CO_2e emissions produced in engine exhaust behind aircraft using WSI's flight paths and route network have been set in the context of projected CO_2e emissions from domestic commercial aviation activity in Australia and NSW. This is aligned to the commitments made by the Australian Government as a party to the UNFCCC and Paris Agreement, which include Australia's 2030 emissions reduction targets and an economy wide 2050 trajectory to net zero emissions. Projections of CO_2e emissions have been obtained from the Australian National Greenhouse Accounts (DCCEEW 2022), a review of Australia's 2019 NIR (DCCEEW 2022) submitted to the UNFCCC (will continue on an annual basis) and the Australian Government's growth rates for commercial aviation activities which formed the basis of longer-term emissions extrapolated in 2055. Consideration was also given to the historic economy wide CO_2e emissions reported by the NSW EPA under the SOE program along with NSW Government future projections of economy wide CO_2e emissions to 2033. This information formed the basis of longer-term CO_2e emissions projected which were extrapolated out to 2055.

Direct impacts associated with the project have been accounted for in the total economy wide GHG emissions for NSW and Australia. GHG emissions from engine use by aircraft operating along WSI's flight paths will be restricted initially to the Sydney Basin airspace, as well as the enroute structures to all flight destinations across the WSI flight route network. Cumulative impacts relating to GHG emissions and the predicted effects of climate change would be restricted to the adjustments required to Sydney Basin operations prior to the opening of WSI in 2026 to facilitate its flight paths and airspace structure. These facilitated airspace changes will alter existing flight path profiles (lateral and vertical) of other airports in the Sydney Basin.

Given the size of the study area and operational timeframes of the project, other relevant projects or developments considered likely to contribute to cumulative impacts have been restricted to those of sufficient scale to contribute materially to cumulative impacts at a regional level with similar overlapping spatial or temporal characteristics. A list of major projects and strategic developments considered for cumulative impacts is provide in Chapter 22 (Cumulative impacts) of the EIS.

Although there are several other recent and proposed projects in the locality that will incrementally exacerbate impacts on GHG emissions there is an extensive network of existing flight paths trafficked by more than 700,000 aircraft (Airservices Australia 2019) over the Sydney Basin and GBMA that already produce GHG emissions.

[32] A GHG emissions budget is the maximum amount of cumulative net global anthropogenic CO_2 emissions that would result in limiting global warming to a given level with a given probability, considering the effect of other anthropogenic forcers.

Furthermore, impacts on the GHG emissions generated by most planned and proposed projects in the Sydney Basin will be limited to energy consumption by on-ground development, the combustion of fuels by transport activities and industrial processes. On an economy wide basis, the GHG emissions from WSI are small. In the years to 2040, these GHG emissions are unlikely to make material difference in the physical risk of future climate change projections, as historic GHG emissions have already been locked in global warning over this timeframe. Beyond this date to 2055, GHG emissions from flight operations at WSI may marginally contribute to potential climate change but not at a level expected to inhibit the Australian Government's commitment made under the Paris Agreement (including the NSW Government) to emissions reduction targets or a net zero emissions transition by 2050.

Technical paper 8: Biodiversity identifies several ecosystem types likely to be affected by anthropogenic GHG emissions including wetlands and temperate forests which occur throughout the Sydney Basin and the GBMA. It indicates that these ecosystems will not be directly impacted upon by the project and are tolerant of seasonal climatic fluctuations.

Impacts associated with the project are being avoided and minimised wherever possible however many of the residual impacts are outside the control of the DITRDCA and operation of WSI's flight paths and route network.

Chapter 11 Management and mitigation measures

There are many available options to minimise tailpipe CO_2e emissions produced in the exhaust plumes behind aircraft engines, however, these are out of the control of the DITRDCA. Therefore, no project specific greenhouse gas emissions mitigations, management measures or monitoring is proposed.

Chapter 12 Conclusion

The GHG assessment has estimated the projected tailpipe CO_2e emissions produced in the engine exhaust behind aircraft using WSI's flight paths and flight route network in 2033 and in 2055 compared to historical and projected economy wide CO_2e emissions reported by the Australian and NSW Governments in 2019, including transport and commercial aviation. It identified that engine use by aircraft operating on WSI's flight paths below 10,000 ft (3,048 m) would emit around 128,778 tonnes of CO_2e in 2033. These emissions have been projected to increase to 441,935 tonnes of CO_2e in 2055 due to 38 new flight routes being added to the WSI network, many of which provide RPT services mostly operated by large, twin-aisle WBJ to medium and long-haul destinations.

Table 12.1 shows the full flight tailpipe CO_2e emissions projected for aircraft departing from WSI and flying to each destination airport across the intrastate (NSW only) and Australian domestic route networks in 2033 and in 2055. The percentage proportion of WSI's projected CO_2e emissions of total CO_2e emissions projected for domestic commercial aviation activities in NSW and Australia are also shown in Table 12.1. Also included in Table 12.1 for reference is the percentage proportion of all projected CO_2e emissions for combined domestic and international commercial aviation activities from WSI to each destination airport across WSI's anticipated route networks in 2033 and 2055.

On an economy wide basis, the projected aircraft tailpipe CO_2e emissions from WSI are small. In the years to 2040, these GHG emissions are unlikely to make material difference in the physical risk of future climate change projections, as historic GHG emissions have already been locked in global warning over this timeframe. Beyond this date to 2055, WSI's GHG emissions would marginally contribute to potential climate change but not at a level expected to inhibit Australia's commitment to emissions reduction targets or a net zero emissions transition by 2050. Future air traffic management improvements, new aircraft technology developments and fuel efficiency gains through scaling the production and use of SAF as well as the emergence of hydrogen have not been assessed. The benefits, in terms of GHG emissions savings, associated with improved operations, aircraft technology and fuel measures (SAF) are expected to result in potentially substantive reductions of aircraft engine CO_2e emissions projected for WSI in 2033 and in 2055.

Table 12.1 Comparisons of projected aircraft tailpipe CO_2e emissions for WSI with projected total economy wide NSW and Australia emissions in 2033 and in 2055

WSI	2033		2055	
	Mt CO_2e	% of total economy wide projected CO_2e emissions	Mt CO_2e	% of total economy wide projected CO_2e emissions
NSW (all intrastate destination airports)	0.02	0.04	0.05	0.2
Australia (all Australian destination airports)	0.45	0.13	0.95	0.5
International (all domestic and international destination airports)	1.75	0.5	8.65	4.9

The most carbon-intensive flights are those operating RPT services to medium and long haul destinations. In 2033 and 2055, these RPT services accounted for only 27 and 23 per cent of projected total departure movements but were responsible for more than half of all full flight emissions of CO_2e. Emissions of CO_2e from domestic aviation are projected to grow steadily between 2033 and 2055, as activity continues to grow generally in line with population. Unlike many other sectors and road-based transport, the decarbonisation of domestic aviation relies on solutions like SAF and advancements in aircraft engine and propulsion system technologies to deliver significant reductions. Aviation is one of the hardest to abate industries with projected wider sectoral decarbonisation across Australia and in NSW reflecting significant Government investment in the acceleration of the renewable energy transition, low emissions technologies and CCS solutions. As these other sectors decarbonise domestic aviation's proportion of total emissions is expected to increase as indicated above.

Wide-ranging measures will be required to manage and reduce emissions of CO_2e from engine use by aircraft operating along WSI's flight paths and route network. These measures are out of the control of DITRDCA and no project specific mitigation, management or monitoring measures are recommended here.

A collaborative approach is required amongst aviation stakeholders including WSA Co, Airservices Australia, the airlines, aerospace manufactures and fuel companies to help WSI operate with the lowest carbon footprint possible. These measures include:

- **Improvement in aircraft fuel efficiency** through fleet renewal and advancements in new generation aircraft design and propulsions systems (i.e., electric and hydrogen powered aircraft).
- **Improvement in aircraft routing and handling** along WSI's flight paths, through the Sydney Basin airspace and Australian enroute networks.
- **Trial new aircraft technologies and operational concepts** designed to decarbonise flight activities.
- **Research in SAF** and establishment of local (Australian) market capability and infrastructure to produce and supply reliable feedstock quantities that are cost competitive to meet outbound demand by various aircraft operators under future offtake agreements.
- **Establishment of aviation industry forums** to share knowledge, learned experience and exchange best practice concepts.

The actual mix of these measures, the exact impact they will have on decarbonising the aviation industry in Australia and globally and the timelines for implementation are uncertain. Nonetheless, bringing these measures to reality are important building blocks to support the Australian Government and NSW Government in achieving their targets of net zero emissions economies by 2050.

Chapter 13 References

Air Transport Action Group (ATAG), 2020. Aviation Benefits Beyond Borders.
At: https://aviationbenefits.org/downloads/aviation-benefits-beyond-borders- 2020.

ATAG. 2021. Fact Sheet #3 – Tracking aviation efficiency. At:
https://aviationbenefits.org/media/167475/factsheet_3_tracking-aviation-efficiency-v2.pdf.

ATAG. 2021. Waypoint 2050. Second Edition. At:
https://aviationbenefits.org/media/167417/w2050_v2021_27sept_full.pdf.

Airbus. 2022. ZEROe – Towards the world's first zero-emission commercial aircraft.
At: https://www.airbus.com/en/innovation/zero-emission/hydrogen/zeroe 104.

Airlines for Australia and New Zealand, 2021. An Australian Roadmap for Sustainable Flying Reaching Net Zero by 2050.

Airlines for Europe et al. 2021. Destination 2050 - A Route to Net Zero European Aviation.

Airports Council International (ACI) EUROPE, 2009. *Airport Carbon Accreditation* Scheme (www.airportcarbonaccreditation.org).

ACI. Airport Carbon Accreditation. At: https://www.airportcarbonaccreditation.org.

ACI World, June 2021. Long-Term Carbon Goal Study for Airports Report.

ACI. 2021. Net zero by 2050: ACI sets global long term carbon goal for airports. Media Release: 08/06/2021.
At: https://aci.aero/2021/06/08/net-zero-by-2050-aci-sets-global-long-term-carbon-goalfor-airports.

ACI-EUROPE, 2020, *Airport Carbon Accreditation* – Application Manual - Issue 12
https://www.airportcarbonaccreditation.org/component/attachments.

Airservices Australia. OneSky Brochure: https://www.airservicesaustralia.com/wp-content/uploads/OneSKY-Brochure-Detailed-Overviewp-web.pdf.

Australian Academy of Science (2021), The Risks to Australia of a 3°C Warmer World, Australian Academy of Science, Canberra.

Australian Government Department of Industry, Science, Energy and Resources, April 2021. National Inventory Report. The Australian Government Submission to the United Nations Framework Convention on Climate Change Australian National Greenhouse Accounts.

Australian Government, October 2021. Australia's Long-Term Emissions Reduction Plan - A whole-of-economy Plan to achieve net zero emissions by 2050.

Australian Government Department of Infrastructure and Regional Development, August 2017. Managing the Carbon Footprint of Australian Aviation. At: https://www.infrastructure.gov.au/sites/default/files/documents/managing-the-carbon-footprint-of-australian-aviation.pdf.

Australian Government Department of Infrastructure and Regional Development, Communications and the Arts. 2022. Australia's State Action Plan – International Civil Aviation Organization (ICAO) Assembly Resolution A37-19 on Climate Change, October 2022.

BITRE (Bureau of Infrastructure, Transport and Regional Economics), 2002. Report 107, Greenhouse Gas Emissions from Transport, Australian Trends to 2020, Canberra. 2022a.Airport traffic data. 1985–86 to 2021–22, Canberra.
https://www.bitre.gov.au/publications/ongoing/airport_traffic_data.

Brisbane Airport, 2022. Sustainability Strategy – Creating Tomorrow, Today.

Brisbane Airport. 2022 Annual Report.

Brisbane Airport. 2022. Media Release: Brisbane Airport accelerates net zero target by 25 years. [5 August 2022].
At: https://newsroom.bne.com.au/brisbane-airport-accelerates-net-zero-target-by-25-years.

CSIRO and Bureau of Meteorology (2022) State of the Climate 2022, Australian Government, Canberra.

CST & WEF. 2021. Clean Skies for Tomorrow: Sustainable Aviation Fuel Policy Toolkit – Insight Report, November 2021. At: https://www3.weforum.org/docs/WEF_Clean_Skies_for_Tomorrow_Sustainable_Aviation_Fuel_Policy_Toolkit_2021.pdf 193.

DCCEEW, 2022. Annual Climate Change Statement 2022 - The first Annual Climate Change Statement to Parliament as required by the Climate Change Act 2022.

DCCEEW, April 2023. National Inventory Report - The Australian Government Submission to the United Nations Framework Convention on Climate Change Australian National Greenhouse Accounts.

DCCEEW, Australian National Greenhouse Accounts. [last accessed 9 May 2023]

DCCEEW, December 2022. Australia's emissions projections 2022.

DCCEEW, February 2023. Australian National Greenhouse Accounts Factors For individuals and organisations estimating greenhouse gas emissions.

DCCEEW, October 2022. Australia's State Action Plan – International Civil Aviation Organization (ICAO) Assembly Resolution A37-19 on Climate Change.

EASA (European Aviation Safety Agency), 1975–2015. International Civil Aviation Organization (ICAO) Aircraft Engine Emissions Databank. https://www.easa.europa.eu/ EEA (European Environment Agency), 2011. EMEP/EEA air pollutant emission inventory guidebook. Copenhagen.

IATA. 2019. Aircraft technology roadmap to 2050. At: https://www.iata.org/contentassets/8d19e716636a47c184e7221c77563c93/Technology-roadmap-2050.pdf.

IATA. 2021. Fly Net Zero Fact Sheet: New Aircraft Technologies. At: https://www.iata.org/contentassets/b3783d24c5834634af-59148c718472bb/factsheet_newaircrafttechnology.pdf.

IATA. 2022. Fly Net Zero Fact Sheet: Sustainable Aviation Fuel. At: https://www.iata.org/en/iata-repository/pressroom/fact-sheets/fact-sheet---alternativefuels.

IATA. 2021. Fly Net Zero Fact Sheet: Operations and Infrastructure. At: https://www.iata.org/en/iata-repository/pressroom/fact-sheets/fact-sheet-netzero-operations-infrastructure/.

International Civil Aviation Organization (ICAO), June 2018. The ICAO Carbon Emissions Calculator Methodology, Version 11.

ICAO, Second Edition 2020. Document 9889, Airport Air Quality Manual.

ICAO. Life Cycle Emissions of Sustainable Aviation Fuels. At: https://www.icao.int/environmental-Protection/pages/SAF_LifeCycle.

International Air Transport Association (IATA). 2021. CORSIA – Fact Sheet. At: https://www.iata.org/en/iata-repository/pressroom/fact-sheets/fact-sheet---corsia.

IATA. 2021. Net-Zero Carbon Emissions by 2050. [Media Release: 04/10/21] At: https://www.iata.org/en/pressroom/2021-releases/2021-10-04-03.

ICAO. 2016. ICAO Environmental Report: On Board – A sustainable future. At: https://www.icao.int/environmental-protection/documents/ICAO%20Environmental%20Report%202016.pdf.

ICAO. 2019. ICAO 2019 Environmental Report: Destination Green – The Next Chapter. At: https://www.icao.int/environmental-protection/pages/envrep2019.aspx.

ICAO. 2022. ICAO 2022 Environmental Report: Innovation for a Green Transition. At: https://www.icao.int/environmental-protection/Pages/envrep2022.aspx.

ICAO. 2022. Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA). At: https://www.icao.int/environmental-protection/CORSIA/Pages/default.aspx.

International Panel on Climate Change (IPCC) (2022) Summary for Policymakers In: Climate Change 2022: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [H.-O. Pörtner, D.C. Roberts, M. Tignor, E.S. Poloczanska, K. Mintenbeck, A. Alegría, M. Craig, S. Langsdorf, S. Löschke, V. Möller, A. Okem, B. Rama (eds.)]. Cambridge University Press, Cambridge, UK and New York, NY, USA, pp. 3–33, doi:10.1017/9781009325844.001.

IPCC (2022b) Summary for Policymakers. In: Climate Change 2022: Mitigation of Climate Change. Contribution of Working Group III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [P.R. Shukla, J. Skea, R. Slade, A. Al Khourdajie, R. van Diemen, D. McCollum, M. Pathak, S. Some, P. Vyas, R. Fradera, M. Belkacemi, A. Hasija, G. Lisboa, S. Luz, J. Malley, (eds.)]. Cambridge University Press, Cambridge, UK and New York, NY, USA. doi: 10.1017/9781009157926.001.

Network for Greening the Financial System, 2022. NGFS Climate scenarios for central banks and supervisors.

NSW Government Department of Planning, Industry and the Environment. Net Zero Plan Stage 1: 2020-2030.

NSW Government, NSW Climate Change Adaptation Strategy.

Qantas, 2022. Sustainability Report – Driving Sustainability to Protect the Future of Travel.

Qantas. 2022. Media Release: Qantas and Airbus Joint Investment to Kickstart Australian Biofuels Industry. [19/06/2022] At: https://www.qantasnewsroom.com.au/media-releases/qantas-and-airbus-joint-investment-to-kickstart-australian-biofuels-industry.

Qantas. 2022. Qantas Group Climate Action Plan. At: https://www.qantas.com/content/dam/qantas/pdfs/about-us/environment/qantas-group-climate-action-plan.pdf.

Qantas. 2022. The next generation of Qantas aircraft. At: https://www.qantas.com/au/en/promotions/new-fleet.html.

Sydney Airport, 2022 Response to the recommendations of the Task Force on Climate-Related Financial Disclosures.

Sydney Airport, Sustainability Report 2021 Looking beyond the challenges.

Sydney Airport, Sustainability Report 2022.

UNEP (2022) Emissions Gap Report 2022: The Closing Window — Climate crisis calls for rapid transformation of societies, United Nations Environment Programme, Nairobi.

United Nations Climate Change. The Paris Agreement. At: https://unfccc.int/process-and-meetings/the-paris-agreement/the-paris-agreement.

Virgin Australia. 2018. Virgin Australia leads Australian first with delivery of sustainable aviation fuel at Brisbane Airport. [Media Release: 11/09/2018]. At: https://newsroom.virginaustralia.com/release/virgin-australia-leads-australian-first-delivery-sustainable-aviation-fuel-brisbane-airport.

Virgin Australia. 2022. Fleet growth positions Virgin Australia for higher capacity, lower emissions. Media Release: 29 April 2022. At: https://newsroom.virginaustralia.com/release/fleet-growth-positions-virgin-australia-higher-capacity-lower-emissions.

World Resource Institute/World Business Council for Sustainable Development, 2004. GHG Gas Protocol, a Corporate Accounting and Reporting Standard.

Western Sydney Airport, 2022. Sustainability Plan, Design and Construction.

Australian Government

Department of Infrastructure, Transport,
Regional Development, Communications and the Arts