V1.0 MARCH 2021

UK AVIATION NET ZERO ACTION PLAN

SUSTAINABLE AVIATION

AOA THE VOICE OF UK AIRPORTS

AIRLINES UK THE ASSOCIATION OF UK AIRLINES

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FOREWORD

Adam Morton
Chair
Sustainable Aviation

SUSTAINABLE AVIATION

With Glasgow hosting the UN Climate Change Conference this year, the eyes of the world will be turned towards the UK and our commitment to decarbonisation.

Publishing this UK Aviation Net Zero Plan underpins our industry's collective contribution to this challenge, adding further ideas and impetus to our work with government through the Jet Zero Council. The stretching but credible targets for aerospace technologies and sustainable fuels, will not only help deliver UK aviation's 2050 net-zero commitment; it will also enable more sustainable connectivity across oceans and continents in the nearer term. The UK is well placed to deliver the key engine, aircraft and fuel technologies to provide global environmental benefits. It is equally well suited to capitalise on the associated expertise and intellectual property, driving export of related goods and services internationally.

As the plan shows, delivering on these opportunities will also rely upon on a coordinated approach to equally challenging policy, regulatory and funding elements. It is for this reason, I am delighted to see wider enabling work included alongside the technology.

Karen Dee
Chief Executive
Airport Operators
Association

AOA
THE VOICE OF UK AIRPORTS

While the pandemic has had major impact on UK aviation, there is also an opportunity to build back better. UK airports are clear sustainability will be at the heart of their recovery. We can and will get back to the passenger levels seen in 2019, but we have an opportunity to ensure that this does not come with the same environmental impacts.

This Action Plan sets out the milestones airports have in their sights to achieve that. As airports are at the heart of their local communities and their local economies, we know building back better will help deliver new, green jobs at a time when so many have lost jobs in aviation. If we get this right, the UK will have a significant competitive advantage in green aviation and we need to work together – as an industry, but also as a country – to achieve that ambition.

FOREWORD

Tim Alderslade
Chief Executive
Airlines UK

No-one could have foreseen the huge impact that the pandemic would have on UK aviation, striking the sector a year ago and just days after the whole UK industry pledged to achieve net zero carbon emissions by 2050. The current crisis is not over and recovery, when it comes, will not arrive overnight. However, throughout this crisis UK airlines, alongside the wider sector, have remained steadfast in their commitment to net zero, understanding that a sustainable recovery is the only way to guarantee our long-term future, as well as reap the strategic benefits that will come from the UK being a world leader in 'jet zero' technology.

This decade of recovery for airlines, must also be a decade of net zero delivery, and this Action Plan sets out the critical milestones around commercialising sustainable fuels, expediting new technology and delivering airspace modernisation that hold the key to making net zero 2050 a reality.

Paul Everitt
Chief Executive
ADS

The UK Aerospace industry is committed to net zero aviation by 2050, demonstrated by the significant investment industry continues to make in advanced technology to deliver this ambition.

We are now at a landmark moment in this challenge, and we have a clear plan to achieve the goal. This is a unique opportunity to position the UK as a global leader in delivering net zero aviation, and by doing so to secure a bright and prosperous future for our aerospace manufacturers, our highly skilled workforces and the communities where they are based.

This Action Plan sets out the milestones that UK aviation, including aerospace manufacturers, must deliver on our journey to net zero. Realising these will require a close partnership between industry and Government, through initiatives like the Jet Zero Council, Aerospace Technology Institute, FlyZero, and the commercialisation of Sustainable Aviation Fuels. Together we can ensure that UK aerospace plays a key role in delivering fully sustainable aviation to the world.

INTRODUCTION

The aviation sector connects the world, enriches lives and drives economies. Aviation stands at an inflection point – the urgency of climate change demands an acceleration in the effort to ensure cleaner more sustainable flight. The UK aviation sector has a shared sense of responsibility, purpose and commitment to this goal.

The sector supports the urgent and immediate call to action to develop radically improved technologies, flight operations and alternatives to fossil fuels to enable an environmentally sustainable future for aviation.

The UK's international leadership role, including the Presidency of COP26 in 2021, presents a unique opportunity for the UK to collectively set out and demonstrate industry's ambition, capability, and strategy to deliver sustainable aviation solutions to the world. Industry is proud and excited to be working with UK Government to deliver on its Jet Zero ambition of net zero emissions for UK aviation by 2050.

JET ZERO 2050 AMBITION

In 2019, the UK became one of the first major world economies to legislate net zero emissions by 2050, requiring the UK to bring all greenhouse gas emissions to net zero by 2050. In February 2020, through the leadership of Sustainable Aviation (SA), the UK Aviation sector committed to reach net-zero carbon emissions by 2050 through the publication of its Decarbonisation Roadmap. In July 2020 UK Government established the Jet Zero Council, whose ambition is for the UK to be a global leader in sustainable aviation and to capture significant industrial, economic and societal value from this transition.

More recently, the Prime Minister's Ten Point Plan for a Green Industrial Revolution, highlighted support for the deployment of sustainable aviation fuels (SAF), and the ATI Fly Zero project was launched to explore the technologies and capabilities required to develop a UK zero emissions aircraft. These all amount to a clear and shared ambition for sustainability across industry, government, and wider aviation stakeholders. What is required is a credible plan which captures the important milestones that need to be delivered to achieve those ambitions.

NET ZERO ACTION PLAN

Taking the SA Decarbonisation Roadmap as a scenario in which projected UK aviation growth is commensurate with our carbon goals, the Action Plan is a roadmap that captures the actions and milestones required to deliver on the sustainability agenda across the air transport industry. These milestones will not only help achieve our ambitious environmental targets, but will give the UK a leading position in delivering sustainable aviation solutions across the world, while creating high-value green jobs right across the country.

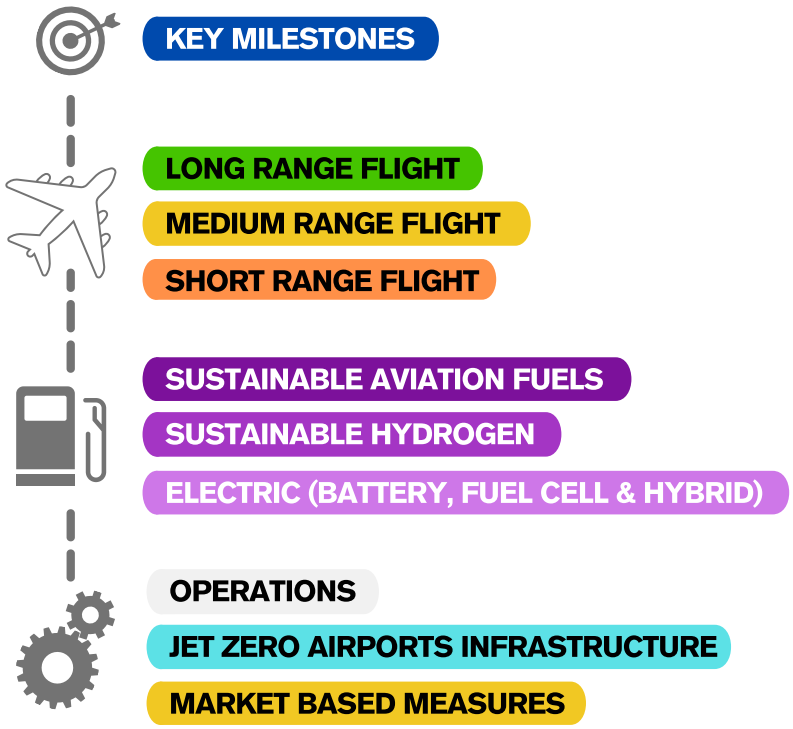
The first of its kind, the Action Plan reflects the strong and deep collaboration that will be needed across all aviation stakeholders, including Government partners, to deliver the ambitious goals.

The Action Plan is structured around the known principal levers of flight decarbonisation, namely new aircraft technologies and alternative energies. Further efficiencies will be gained from improved flight operations enabled by airspace modernisation. Airports will play a key role in enabling the transition to new aircraft and alternative energies. Finally, residual carbon emission will need to be mitigated through appropriate market based measures.

The Action Plan reflects all of these opportunities through a set of milestones, tangible outcomes that industry and government should seek to deliver in partnership, to enable meeting of the collective goal; these include industry led projects, policy interventions, and public investments into the sector.

ACTION PLAN STRUCTURE

There are numerous ways in which a holistic plan of this nature could be structured, given the interdependencies between the different levers and milestones, and the collaborations that will be needed to realise them. The final structure was chosen to aid stakeholder engagement in building the plan and to ensure the output was visually simple and engaging to a broad range of stakeholders.



KEY MILESTONES

This is a summary of the key milestones from across the 'swim lanes' in the Action Plan, and key markers in the timeline towards net zero carbon 2050. First and foremost, increased funding for aerospace R&D and financial support for the commercialisation of SAFs in the UK are critical to secure in the very short term, to unlock the longer term decarbonisation plan.

The next three swim lanes reflect the aircraft technologies needed to deliver net zero carbon, based on broad range-fuel understanding. There is much research and analysis being conducted at present to better determine the aircraft configurations and energy sources that are optimal (sustainability, engineering, wider systems, economic, commercial) for various range segments of flight.

LONG RANGE FLIGHT

This range is expected to be decarbonised largely through the relentless pursuit of aircraft and engine efficiencies, and the adoption of a drop-in sustainable aviation fuels. Milestones here reflect the introduction of ultra-efficient turbofan engines, and certifying engines and aircraft to use 100% SAFs. Major aircraft manufactures have plans to certify their entire large commercial fleets for 100% SAF by 2030.

MEDIUM RANGE FLIGHT

Whilst the pathways for decarbonising the long-range segment are equally applicable to medium range, this segment also has the greatest opportunity for alternative energies to power future aircraft, and the novel aircraft configurations that maximise their potential. Energy sources here include the use of hydrogen as well as electrical power in hybrid propulsion systems. The ATI FlyZero study will be conducting vital feasibility and trade off analyses to identify range-fuel aircraft configurations, with demonstrators of preferred aircraft configurations featuring in this swim lane in future iterations of the Action Plan. Airbus has already launched its hydrogen powered ZEROe aircraft concepts. Some technologies from this swim lane could well be scaled-up to apply into longer range aircraft in future years.

SHORT RANGE FLIGHT

This segment has the opportunity to be fully electric, powered by batteries or hydrogen fuels cells. Electric propulsion technologies have an intrinsic limitation in range due to Size, Weight and Power density (SWAP) issues. While this segment of aviation presents a relatively smaller contribution to decarbonise aviation, it enables advanced air mobility solutions which will allow a new form of sustainable air transport to connect existing urban and sub-regional transport networks, with the potential for some of the technologies developed to be scaled-up and applied to longer range and larger aircraft.

Extending and increasing investment into the Aerospace Technology Institute is the key enabler to deliver the aircraft technology milestones.

The next three swim lanes reflect the energy sources that will power future flights. Each energy source has a role to play based on the aircraft configuration, mission range and the economics of the flight – there is broad consensus in industry that all of these energies will be required to deliver sustainable aviation.

SUSTAINABLE AVIATION FUELS

SAF can significantly reduce net aviation carbon emissions from today. They replace current fossil fuels and require no significant changes to aircraft or infrastructure at airports. Moreover, they will continue to play a significant role in reducing emissions well into the future. Even with the most aggressive technology advancements, kerosene-like liquid fuels will still be required for powering aircraft well into the 2050s, especially on long-range routes.

The milestones in this swim lane reflect what must be done to address the key challenge with SAF – enabling airlines to fill aircraft with a cost effective, reliable, high-volume supply of SAF. Key to this is using policy and finance instruments to establish first-of-kind SAF plants in the UK, which will scale with market uptake.

Today, SAF can be produced by methods including the use of waste residues as a feedstock. The future aspiration is to use Hydrogen from water and green carbon dioxide as feedstocks for "power to liquid" fuels – with all refining and manufacturing processes powered by green electricity. These "e-fuels" offer a truly net-zero emission solution.

The industry agrees that to realise the SAF opportunity and establish a SAF industry in the UK, the support announced last year, for a UK SAF clearing house to enable fuel testing alongside a £15m competition to support UK SAF production, needs to be built upon. Strong additional policy mechanisms on revenue support are needed to enable project financing and deliver major milestones, alongside loan guarantees or finance mechanisms such as Green Bonds that will be critical to attract private investment into this nascent industry.

SUSTAINABLE HYDROGEN

Delivery of better performing aircraft and engines, powered by SAF, will enable significant reductions in aerospace related carbon emissions. However, these alone will not achieve our collective goal of net zero. This will require the development of a new generation of technologies. Hydrogen power is one such exciting development with the potential to make huge strides towards decarbonising aviation. Hydrogen is widely recognised as a critical low carbon energy source to meet global net zero ambitions. There are two technology options: hydrogen combustion where liquid hydrogen feeds a derivative of a conventional gas turbine: and hydrogen fuel cells where hydrogen is used to produce electricity.

The UK needs a robust hydrogen policy and strategy that enables the production of green hydrogen in the volumes required by aviation. The use of hydrogen in aviation will require developments at airports to safely store and use hydrogen, well upstream of when hydrogen powered aircraft enter the market.

ELECTRIC (BATTERY, FUEL CELL & HYBRID)

Significant progress is being made in battery technology which will be best applied to short range and/or small payload aircraft. The expansion of urban air mobility, supported by this technology, offers several benefits. Identifying and maturing these technologies will allow industry to scale up to longer range aviation, however it is recognised that this will be a small part of reducing the environmental impact of aviation as a whole.

Whilst significant reductions in emissions can be achieved through technology and energy sources, swift progress is required in other key areas that are critical contributors to the sector's overall net zero ambitions.

OPERATIONS

An important proportion of aviation carbon emissions can be abated through redesigning airspace, electrification of ground operations, and using data, digital and other technologies to optimise flight routes and operations. Flight operations will also play an important role in avoiding contrail formation, as we increasingly understand the impacts of non-CO2 effect on climate change.

JET ZERO AIRPORT INFRASTRUCTURE

Airports will play a vital role in enabling the use of future aircraft and fuels. In particular, to embrace electric and hydrogen powered flight, airports will need to establish the right infrastructure and operational procedures. To unlock investment in this area, and provide a common approach, global standards are required. All parts of the UK industry and Government, must work to ensure these standards are developed and published; drawing on the technical expertise within the manufacturer, airport, airline and air navigation services community and learning from the early use of electric and hydrogen power on the ground at airports.

MARKET BASED MEASURES

Residual emissions from the sector will need to be addressed outside of Aviation, through a variety of market-based measures (MBMs) that remove carbon. These include advanced technologies such as carbon capture and storage. While those technologies come to maturity, carbon trading and offsetting schemes will be an important tool to help aviation reach its environmental goals. These measures will not be a replacement for in-sector efforts.

The Action Plan demonstrates that through a combination of solutions, realised by strong and ambitious collaborations between industry and government, there are clear pathways to delivering the collective goal of net zero carbon for UK aviation. In doing so, the UK can position itself as a world leader in sustainable aviation.

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2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2030 | 2035 | 2040 | 2045 | 2050

KEY MILESTONES

- COMMITMENT TO DOUBLE & EXTEND ATI BEYOND 2030
- CONTRACT TO DOUBLE & EXTEND ATI BEYOND 2030
- LONG-TERM SAF COMMERCIALISATION COMMITMENT
- COP26
- FLYZERO STRATEGIC ROADMAP & BUSINESS CASE
- PUBLICATION OF ICAO LONG-TERM ASPIRATIONAL GOAL
- 100% SAF TRANSATLANTIC VOYAGER
- INITIAL INDUSTRY STANDARDS FOR NET ZERO AIRCRAFT
- UK ZERO-EMISSION REGIONAL AIRCRAFT IN SERVICE
- ICAO PROGRESS CHECK
- UK ZERO-EMISSION TRANSATLANTIC AIRCRAFT IN SERVICE
- NET ZERO GOAL
- NET ZERO GOAL

LONG RANGE FLIGHT

- 100% SAF GROUND-BASED ENGINE DEMONSTRATION
- 100% SAF FLYING DEMONSTRATOR
- WING OF TOMORROW DEMONSTRATOR
- 100% SAF CERTIFIED FOR ALL LARGE PLATFORMS
- RR ULTRAFAN ENTERS SERVICE

MEDIUM RANGE FLIGHT

- WORLD'S FIRST RESIN-INFUSED CERTIFIED WING (A220)
- AIRBUS ZERO-E CONCEPT AND TECHNOLOGY SELECTION (TRL 3)
- AIRBUS ZERO-E TRL 6
- AIRBUS ZERO-E FLIGHT DEMONSTRATOR
- HYDROGEN-ELECTRIC TURBOPROP REGIONAL AIRCRAFT ENTRY INTO SERVICE
- AIRBUS ZERO-E ENTRY INTO SERVICE
- RR ULTRAFAN MEDIUM RANGE

SHORT RANGE FLIGHT

- FIRST HYDROGEN-ELECTRIC SUBREGIONAL FLIGHT DEMONSTRATOR
- ELECTRIC FLIGHT WORLD SPEED RECORD
- FIRST FUTURE FLIGHT URBAN AIR DEMONSTRATOR
- HYDROGEN-ELECTRIC SUBREGIONAL AIRCRAFT ENTRY INTO SERVICE

SUSTAINABLE AVIATION FUELS

- FINANCING AGREED (SAF)
- LAUNCH OF SAF CLEARING HOUSE
- SAF AT COP26
- POLICY CERTAINTY ON SAF SUPPORT MECHANISMS
- SAF POLICY BRIDGE
- LAUNCH OF SAF COMPETITION
- POWER TO LIQUID STRATEGY
- NEW SAF PATHWAYS PROGRESSED VIA CLEARING HOUSE
- FIRST AT SCALE PLANT
- SUFFICIENT SAF FOR ALL DOMESTIC FLIGHTS
- SUFFICIENT PTL FOR ALL DOMESTIC FLIGHTS
- UK SAF INDUSTRY ESTABLISHED
- SUFFICIENT SAF TO MEET >30% OF UK AVIATION FUEL DEMAND

SUSTAINABLE HYDROGEN

- HYDROGEN POLICY
- HYDROGEN IN AVIATION STRATEGY
- GREEN HYDROGEN PRODUCTION SCALING PLAN
- UK FIRST LARGE AIRPORT PAIRS WITH AVIATON HYDROGEN
- HYDROGEN SUPPLY CHAIN TO AIRPORTS

ELECTRIC (BATTERY, FUEL CELL, HYBRID)

- UK AEROSPACE ELECTRIFICATION CENTRE LAUNCH
- 1MW LIQUID HYDROGEN FUEL CELL PROPULSION SYSTEM GROUND DEMONSTRATOR

GREEN ELECTRICITY SUPPLY

INCREASING GREEN ELECTRICITY DEMAND FROM AVIATION

- SMRS CONNECT TO GRID

OPERATIONS

- CONTRAIL AVOIDANCE DEMONSTRATION
- FORMATION FLYING DEMONSTRATION
- FREE ROUTES FLOWN ACROSS UK
- OCEANIC OPTIMISATION USING SPACE BASED NAVIGATION
- REDUCED HOLDING USING MULTI-AIRPORT ARRIVALS MANAGEMENT
- AIRSPACE MODERNISATION: RE-DESIGN OF LOWER AIRSPACE
- 4D TRAJECTORY MANAGEMENT

JETZERO AIRPORT INFRASTRUCTURE

- FIRST COMMERCIAL DEMONSTRATOR OF ELECTRIC, H2 & SAF REGIONAL ROUTES
- ELECTRIC GROUND POWER UNITS ON NEW STANDS
- FIRST REGIONAL AIRPORT WITH ELECTRIC, H2 & SAF INFRASTRUCTURE
- ONSITE/DIRECT RENEWABLE ELECTRICITY SUPPLY
- SAF SUPPLY AVAILABLE AT LEAD AIRPORTS
- AIRCRAFT APU SUBSTITUTIONS UNDERWAY
- AUTOMATED/ ELECTRIC TAXIING ENABLED
- EV/V2G SYSTEMS AT AIRPORTS
- LARGE SCALE GREEN ELECTRICITY PLANS IN PLACE
- AIRPORT H2 SUPPLY CHAINS IN PLACE
- FIRST JET ZERO AIRPORTS

MARKET BASED MEASURES

- £100M INVESTMENT IN GREENHOUSE GAS REMOVALS
- AVIATION INCLUDED IN UK 6TH CARBON BUDGET ANNOUNCEMENT
- CORSIA BEGINS
- EU ETS REVISION
- FIRST REVIEW
- EU ETS END MARKET STABILITY RESERVE
- UK ETS FIRST REVIEW
- EU ETS SCOPE REVIEW
- PHASE ONE
- 2 CARBON CAPTURE, UTILISATION & STORAGE CLUSTERS
- UK ETS SECOND REVIEW
- SECOND REVIEW
- PHASE TWO
- 4 CARBON CAPTURE, UTILISATION & STORAGE CLUSTERS
- UK ETS PHASE 1 END
- INDIVIDUAL SHARES BEGIN
- SPECIAL REVIEW
- INDIVIDUAL SHARES INCREASE

2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2030 | 2035 | 2040 | 2045 | 2050

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