Department for Transport

UK State Action Plan on International Aviation CO_2 Emissions Reduction Activities

June 2021

Department for Transport
Great Minster House
33 Horseferry Road
London
SW1P 4DR

This publication is also available on our website at
www.gov.uk/government/organisations/department-for-transport

Any enquiries regarding this publication should be sent to us at
www.gov.uk/government/organisations/department-for-transp

Contents

Contact Information

Name of Authority: UK Department for Transport

Point of Contact: Rannia Leontaridi
(Director General Civil Aviation)

Address: Great Minster House, 33 Horseferry Road, London, SW1P 4DR

Country: United Kingdom

Point of Contact: Holly Greig
(Deputy Director - Aviation Decarbonisation Division)

Email: Holly.Greig2@dft.gov.uk

Point of Contact: Ben Taylor
(Senior Policy Advisor, Aviation Decarbonisation Division)

Email: Ben.Taylor1@dft.gov.uk

1. Introduction

1.1 The United Kingdom is an International Civil Aviation Organisation (ICAO) Contracting State and a member of the European Civil Aviation Conference (ECAC). ECAC is an intergovernmental organisation covering the widest grouping of Member States[1] of any European organisation dealing with civil aviation. It is currently composed of 44 Member States and was created in 1955

1.2 ECAC States share the view that the environmental impacts of the aviation sector must be mitigated if aviation is to continue to be successful as an important facilitator of economic growth and prosperity. ECAC States agree an urgent need to achieve the ICAO goal of Carbon Neutral Growth from 2020 onwards (CNG2020) and to strive for further emissions reductions. Together, they fully support ICAO's on-going efforts to address the full range of those impacts, including the key strategic challenge posed by climate change, for the sustainable development of international air transport.

1.3 All ECAC States, in application of their commitment in the 2016 Bratislava Declaration, support implementation of the Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA) and have notified ICAO of their decision to voluntarily participate in CORSIA from the start of its pilot phase and have effectively engaged in its implementation.

1.4 The United Kingdom, like all of ECAC's 44 States, is fully committed to and involved in the fight against climate change and works towards a resource-efficient, competitive and sustainable multimodal transport system.

1.5 The United Kingdom recognises the value of each state preparing and submitting to ICAO an updated State Action Plan for CO_2 emissions reductions as an important step towards the achievement of the global collective goals agreed since the 38th Session of the ICAO Assembly in 2013.

1.6 In that context, it is the intention that all ECAC States submit to ICAO an action plan[2]. This is the action plan of the United Kingdom.

1.7 The United Kingdom strongly supports the ICAO basket of measures as the key means to achieve ICAO's CNG2020 target and shares the view of all ECAC States

---

1 Albania, Armenia, Austria, Azerbaijan, Belgium, Bosnia and Herzegovina, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Georgia, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Moldova, Monaco, Montenegro, Netherlands, North Macedonia, Norway, Poland, Portugal, Romania, San Marino, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey, Ukraine, and the United Kingdom.

2 ICAO Assembly Resolution A40-18 also encourages States to submit an annual reporting of international aviation CO_2 emissions, which is a task different in nature and purpose to that of action plans, strategic in their nature. Also this requirement is subject to different deadlines for submission and updates as annual updates are expected. For that reason, the reporting to ICAO of international aviation CO_2 emissions referred to in paragraphs 10 & 14 of ICAO Resolution A40-18 is not necessarily part of this Action Plan, and may be provided separately, as part of routine provision of data to ICAO, or in future updates of this action plan.

that a comprehensive approach to reducing aviation CO_2 emissions is necessary, and that this should include:

i. emission reductions at source, including ECAC support to the Committee on Aviation Environmental Protection's (CAEP) work in this matter (standard setting process);

ii. research and development on emission reductions technologies, including public-private partnerships;

iii. development and deployment of sustainable aviation fuels, including research and operational initiatives undertaken jointly with stakeholders;

iv. improvement and optimisation of Air Traffic Management and infrastructure use within Europe, in particular through the Single European Sky ATM Research (*SESAR),* and also beyond European borders through participation in international cooperation initiatives; and

v. market based measures, which allow the sector to continue to grow in a sustainable and efficient manner, recognizing that the measures at (i) to (iv) above cannot, even in aggregate, deliver in time the emissions reductions necessary to meet the ICAO 2020 CNG global goal.

1.8 Within ECAC, some mitigating actions are taken collectively. They are reported in Chapter 4 of this Action Plan, where the involvement of the United Kingdom is described, as well as that of other stakeholders.

1.9 In the United Kingdom, a number of mitigating actions are undertaken at the national level, including those by UK stakeholders. These national actions are reported in Chapter 6 of this Plan.

1.10 In relation to the actions described in Chapter 4, it is important to note that:

1.11 The extent of participation will vary from one state to another, reflecting the priorities and circumstances of each state (economic situation, size of its aviation market, historical and institutional context, such as EU/non EU). The ECAC states are thus involved in different degrees and on different timelines in the delivery of these common actions. When an additional state joins a collective action, including at a later stage, this broadens the effect of the measure, thus increasing the ECAC contribution to meeting the global goals.

1.12 Acting together, the ECAC States have undertaken measures to reduce the region's emissions through a comprehensive approach. Some of the measures, although implemented by some, but not all of ECAC's 44 States, nonetheless yield emission reduction benefits across the whole of the region (for example research, sustainable aviation fuel promotion or emissions trading schemes).

2. Current state of aviation in the UK

Global Britain – Aviation in the UK

2.1 The UK, throughout its history, has always valued global connectivity. The UK's transport network has been vital in ensuring trade and commerce, as well as enabling UK citizens to connect with people from all over the globe. Since the middle of the last century, aviation has played a significant role in moving both people and goods to, from and within the UK. The UK also realises the environmental impacts of aviation have grown as the sector has expanded and are likely to continue to increase unless robust mitigation measures are put in place. The UK is committed to taking action to address the environmental impacts of aviation, taking into account the latest scientific evidence and research to inform these policy decisions.

State of UK Aviation

2.2 The aviation sector provides the major means of travelling to and from the UK, as shown in Table 1a below.

Table 1a: International Passenger Survey 2019

2019	Foreign residents (including EU residents): visits to the UK	UK residents: visits abroad
Air	32,137,187	79,534,155
Sea	4,460,432	7,149,559
Tunnel	4,259,829	6,402,058
Total	40,857,448	93,085,772

2.3 The UK's aviation sector faced severe disruption in 2020 due to the COVID-19 pandemic. Initial data from 2020 in comparison to 2019 can be seen in Table 1b.

2.4 In 2019, almost 80 million visits abroad were undertaken via air transport by UK residents. This compares to only 24 million total visits (air, sea and tunnel) for 2020. There was an overall reduction of 73 % and 74 % in visits to the UK and visits from the UK respectively when comparing 2020 to 2019.

Table 1b: International Passenger Survey 2020 (at the time of publication only total data was available for 2020)		
2020	**Foreign residents (including EU residents): visits to the UK (rounded)**	**UK residents: visits abroad (rounded)**
Air	-	-
Sea	-	-
Tunnel	-	-
Total	11,101,000	23,827,000
Percentage change from 2019	-73%	-74%

2.5 Table 2 shows the top ten commercial airports in terms of passenger numbers in 2019 and 2020. The percentage change between the two years can be seen in Figure 1.

Table 2: Passenger numbers from CAA Airport Statistics, 2019-20			
Top 10 UK airports in 2019 by terminal passengers only		**Top 10 UK airports in 2020 by terminal passengers only**	
HEATHROW	80,302,225	HEATHROW	22,109,550
GATWICK	46,782,033	GATWICK	10,171,867
MANCHESTER	28,746,556	STANSTED	7,536,869
STANSTED	27,586,624	MANCHESTER	7,028,075
LUTON	18,774,755	LUTON	5,550,172
EDINBURGH	14,798,192	EDINBURGH	3,473,652
BIRMINGHAM	12,579,246	BIRMINGHAM	2,862,855
GLASGOW	9,350,371	BRISTOL	2,192,396
BRISTOL	9,111,934	GLASGOW	1,944,981
BELFAST INTERNATIONAL	6,196,608	BELFAST INTERNATIONAL	1,746,774

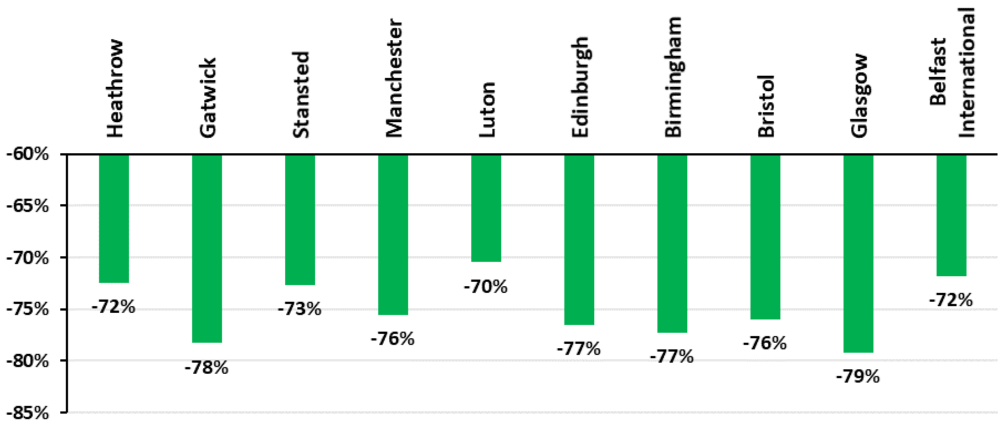


Figure 1: Percentage change in passenger numbers (terminal) in 2020 compared with 2019.

UK Aviation Governance

Department for Transport (DfT)

2.6 The UK Department for Transport (DfT) is the Government Department responsible for aviation policy and undertakes international negotiations on aviation matters. The Secretary of State for Transport leads the department and the Aviation Minister is responsible for aviation related matters. The Aviation Directorate within DfT handles the majority of aviation related policy issues, including policy measures and international negotiations on aviation and climate change. The UK's Director General of Civil Aviation (DGCA) leads this directorate.

Civil Aviation Authority (CAA)

2.7 The CAA is the UK's independent aviation and airspace regulator. Its mission is to improve aviation and aerospace for consumers and the public. Its key priority is the continued safety and security of aviation and aerospace, and protection of consumers.

2.8 While the CAA does not have a primary duty on the environment, recognising that managing and mitigating the environmental impacts associated with the sector is the single biggest challenge to aerospace, one of its key strategic focus areas is on improving environmental performance.

NATS

2.9 NATS is the main air navigation service provider in the United Kingdom. NATS provides en-route air traffic control services to flights within the UK Flight Information Regions and the Shanwick Oceanic Control Area in the North Atlantic, and provides air traffic control services to civil and military airports in the UK and Gibraltar.

2.10 NATS shares responsibility for the design of low-level airspace (0 – 7,000 ft) with airports and is working closely with the airport operators and the Airspace Change Organising Group (ACOG) to develop the Airspace Modernisation Strategy masterplan. NATS is solely responsible for the design of airspace above 7,000 ft.

2.11 NATS is a founding member of the UK's 'Sustainable Aviation' industry coalition, NATS also sits on various UK national fora and represents the UK on CAEP Working Group 2 within ICAO, the technical working group of CAEP responsible for producing guidance for airports and operations .

UK Airports

2.12 The UK benefits from a strong and substantially privatised airport sector, with a regulatory system that supports growth while protecting the interests of passengers. UK airports are critical infrastructure in that they facilitate trade in essential and time-sensitive goods and services, enable the movement of workers and tourists, and driving business innovation and investment, being particularly important for many of the fastest growing sectors of the economy.

2.13 DfT's Airports and Infrastructure Directorate is responsible for airport policy measures and maintains strong engagement links with the sector (primarily airports, ground handlers and trade bodies) as a key component of Government strategy and future policy development.

European Civil Aviation Conference (ECAC)

2.14 The European Civil Aviation Conference is an intergovernmental organisation that seeks to align civil aviation policies across Europe. The UK is a founding member state of ECAC and continues to play an active role in all ECAC activities.

2.15 The environment is a key priority for ECAC and is managed through the Environmental Programme Management Group (EPMG) and the European Aviation and Environment Working Group (EAEG). In 2020, the UK's Director General for Civil Aviation was appointed ECAC Focal Point for Environment matters.

Overseas Territories and Crown Dependencies

2.16 The UK is responsible for a number of Overseas Territories and Crown Dependencies which are covered by the UK's ratification of the ("Chicago") Convention on International Civil Aviation. DfT is responsible for ensuring that the UK's obligations under the Convention are implemented in these territories.

2.17 The territories are:

1. Anguilla
2. Bermuda
3. British Indian Ocean Territory
4. British Virgin Islands
5. Cayman Islands
6. Falkland Islands
7. Gibraltar
8. Bailiwick of Guernsey
9. Isle of Man
10. Bailiwick of Jersey
11. Montserrat
12. Pitcairn, Henderson, Ducie and Oeno Islands
13. South Georgia and South Sandwich Islands
14. St Helena, Ascension and Tristan da Cunha
15. Turks and Caicos Islands

2.18 The UK encourages the overseas territories to consider climate change impacts when making decisions on aviation policy and where appropriate to share best practice. However, for the purposes of reporting greenhouse gas emissions for the UK's carbon budgets the Crown Dependencies and Overseas Territories are excluded - only emissions within the UK are reported.

3. The European Civil Aviation Conference (ECAC) common section

Executive summary

3.1 The European section of this action plan presents a summary of the actions taken collectively throughout the 44 States of the European Civil Aviation Conference (ECAC) to reduce CO_2 emissions from the aviation system and which are relevant for each State, and provides an assessment of their benefit against an ECAC baseline. It also provides a description of future measures aimed to provide additional CO_2 savings.

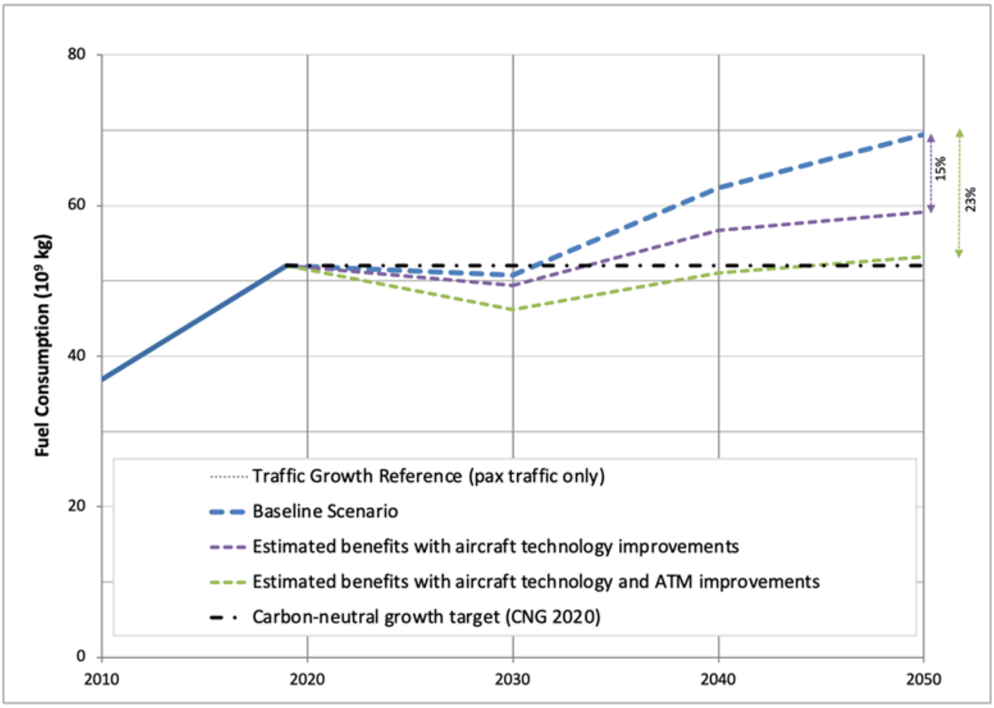
3.2 Aviation is a fundamental sector for the European economy, and a very important means of connectivity, business development and leisure for European citizens and visitors. For over a century, Europe has promoted the development of new technology, and innovations to better meet societies' needs and concerns, including addressing the sectorial emissions affecting the climate.

3.3 Since 2019, the COVID-19 pandemic has generated a world-wide human tragedy, a global economic crisis and an unprecedented disruption of air traffic, significantly changing European aviation's growth and patterns and heavily impacting the aviation industry. The European air transport recovery policy is aiming at accelerating the achievement of European ambitions regarding aviation and climate change.

Aircraft related technology

3.4 European members have actively contributed to support progress in the ICAO Committee on Aviation Environmental Protection (CAEP). This contribution of resources, analytical capability and co-leadership has facilitated leaps in global certification standards that have helped drive the markets demand for technology improvements. Europe is now fully committed on the implementation of the 2017 ICAO CO_2 standard for newly built aircraft and on the need to review it on a regular basis in light of developments in aeroplane fuel efficiency.

3.5 Environmental improvements across the ECAC States are knowledge-led and at the forefront of this is the Clean Sky EU Joint Undertaking that aims to develop and mature breakthrough "clean technologies". The second joint undertaking (Clean Sky 2 – 2014-2024) has the objective to reduce aircraft emissions and noise by 20 to 30% with respect to the latest technologies entering into service in 2014. Under the Horizon Europe programme for research and innovation, the European Commission has proposed the set-up of a European Partnership for Clean Aviation (EPCA) which will follow in the footsteps of CleanSky2, recognizing and exploiting the interaction



between environmental, social and competitiveness aspects of civil aviation, while maintaining sustainable economic growth. For such technology high end public-private partnerships to be successful, and thus, benefit from this and from future CO_2 action plans, securing the appropriate funding is key.

3.6 The main efforts under Clean Sky 2 include demonstrating technologies: for both large and regional passenger aircraft, improved performance and versatility of new rotorcraft concepts, innovative airframe structures and materials, radical engine architectures, systems and controls and consideration of how we manage aircraft at the end of their useful life. This represents a rich stream of ideas and concepts that, with continued support, will mature and contribute to achieving the goals on limiting global climate change. The new European Partnership for Clean Aviation (EPCA) has objectives in line with the European Green Deal goals to reach climate neutrality in 2050 and will focus on the development of disruptive technologies and maximum impact.

Sustainable Aviation Fuels (SAF)

3.7 ECAC States are embracing the introduction of sustainable aviation fuels (SAF) in line with the 2050 ICAO Vision and are taking collective actions to address the many current barriers for SAF widespread availability or use in European airports.

3.8 The European collective SAF measures included in this Action Plan focuses on its CO_2 reductions benefits. Nevertheless SAF has the additional benefit of reducing air pollutant emissions of non-volatile Particulate Matter (nvPM), which can provide important other non-CO_2 benefits on the climate which are not specifically assessed within the scope of this Plan.

Improved Air Traffic Management

3.9 The European Union's Single European Sky (SES) policy aims to transform Air Traffic Management (ATM) in Europe towards digital service provision, increased capacity reduced ATM costs with high level of safety and 10% less environmental impact. SES policy has several elements, one of which is developing and deploying innovative technical and operational ATM solutions.

3.10 SESAR 1 (from 2008 to 2016), SESAR 2020 (started in 2016) and SESAR 3 (starting in 2022) are the EU programmes for the development of SESAR solutions. The SESAR solutions already developed and validated are capable of providing: 21% more airspace capacity; 14% more airport capacity; a 40% reduction in accident risk; 2.8% less greenhouse emissions; and a 6% reduction in flight costs. Future ATM systems will be based on 'Trajectory-based Operations' and 'Performance-based Operations'.

3.11 Much of the research to develop these solutions is underway and published results of the many earlier demonstration actions confirm the challenge but give us confidence that the goals will be achieved in the ECAC region with widespread potential to be replicated in other regions.

Market Based Measures (MBMs)

3.12 ECAC States, in application of their commitment in the 2016 Bratislava Declaration, have notified ICAO of their decision to voluntarily participate in Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA) from its pilot phase, and have effectively engaged in its implementation and they encourage other States to do likewise and join CORSIA.

3.13 ECAC States have always been strong supporters of a market-based measure scheme for international aviation to incentivise and reward good investment and operational choices, and so welcomed the agreement on CORSIA.

3.14 From 2005 to 2020 the UK participated as one 30 European Economic Area (EEA) States in the EU Emissions Trading System (ETS), including the aviation sector with around 500 aircraft operators participating in the cap-and-trade approach to limit CO_2 emissions.

3.15 As a consequence of the linking agreement with Switzerland, from 2020 the EU ETS was extended to all departing flights from the EEA to Switzerland, and Switzerland applies its ETS to all departing flights to EEA airports, ensuring a level playing field on both directions of routes.

3.16 In the period 2013 to 2020, EU ETS has saved an estimated 200 million tonnes of intra-European aviation CO_2 emissions.

3.17 In accordance with the EU-UK Trade and Cooperation Agreement reached in December 2020, the EU ETS shall continue to apply to departing flights from the EEA to the UK, while a UK ETS will apply effective carbon pricing on flights departing from the UK to the EEA.

3.18 From 1 January 2021 the UK has implemented its own UK Emissions Trading Scheme (UK ETS) which also includes aviation. See chapter 6 for more information.

ECAC Scenarios for Traffic and CO_2 Emissions

3.19 The scenarios presented in this common section of State Action Plans of ECAC States take into account the impacts of the COVID-19 crisis on air transport, to the extent possible, and with some unavoidable degree of uncertainty. The best-available data used for the purposes of this action plan has been taken from EUROCONTROL's regular publication of comprehensive assessments of the latest traffic situation in Europe.

3.20 Despite the current extraordinary global decay on passengers' traffic due to the COVID-19 pandemic, hitting European economy, tourism and the sector itself, aviation is expected to continue to grow in the long-term, develop and diversify in many ways across the ECAC States. Air cargo traffic has not been impacted as the rest of the traffic and thus, whilst the focus of available data relates to passenger traffic, similar pre-COVID forecasted outcomes might be anticipated for cargo traffic both as belly hold freight or in dedicated freighters.

3.21 The analysis by EUROCONTROL and EASA have identified the most likely scenario of influences on future traffic and modelled these assumptions out to future years. On the basis of this traffic forecast, fuel consumption and CO_2 emissions of aviation have been estimated for both a theoretical baseline scenario (without any additional mitigation action) and a scenario with estimated benefits from mitigation measures implemented since 2019 or provided benefits beyond 2019 that are presented in this action plan.

3.22 Under the baseline assumptions of traffic growth and fleet rollover with 2019 technology, CO_2 emissions would significantly grow in the long-term for flights departing from ECAC airports without mitigation measures. Modelling the impact of improved aircraft technology for the scenario with implemented measures indicates an overall 15% reduction of fuel consumption and CO_2 emissions in 2050 compared to the baseline. Whilst the data to model the benefits of ATM improvements may be less robust, they are nevertheless valuable contributions to reduce emissions further. Overall CO_2 emissions, including the effects of new aircraft types and ATM-related measures, are projected to improve to lead to a 23% reduction in 2050 compared to the baseline.

3.23 In the common section of this action plan the potential of sustainable aviation fuels and the effects of market-based measures have not been simulated in detail. Notably, CORSIA being a global measure, and not a European measure, the assessments of its benefits were not considered required for the purposes of the State Action Plans. But they should both help reach the ICAO carbon-neutral growth 2020 goal. As further developments in policy and technology are made, further analysis will improve the modelling of future emissions.

ECAC Baseline Scenario

3.24 The baseline scenario is intended to serve as a reference scenario for CO_2 emissions of European aviation in the absence of any of the mitigation actions described later in this document. The following sets of data (2010, 2019) and forecasts (for 2030, 2040 and 2050) were provided by EUROCONTROL for this purpose:

- European air traffic (includes all commercial and international flights departing from ECAC airports, in number of flights, revenue passenger kilometres (RPK) and revenue tonne-kilometres (RTK);
- its associated aggregated fuel consumption; and
- its associated CO_2 emissions.

3.25 The sets of forecasts correspond to projected traffic volumes in a scenario of "Regulation and Growth", while corresponding fuel consumption and CO_2 emissions assume the technology level of the year 2019 (i.e. without considering reductions of emissions by further aircraft related technology improvements, improved ATM and operations, sustainable aviation fuels or market-based measures).

Traffic Scenario "Regulation and Growth"

3.26 As in all forecasts produced by EUROCONTROL, various scenarios are built with a specific storyline and a mix of characteristics. The aim is to improve the understanding of factors that will influence future traffic growth and the risks that lie ahead. The latest EUROCONTROL long-term forecast was published in June 2018 and inspects traffic development in terms of Instrument Flight Rule (IFR) movements to 2040.

3.27 In the latter, the scenario called ‘Regulation and Growth’ is constructed as the ‘most likely’ or ‘baseline’ scenario for traffic, most closely following the current trends[3]. It considers a moderate economic growth, with some regulation particularly regarding the social and economic demands.

3.28 Amongst the models applied by EUROCONTROL for the forecast, the passenger traffic sub-model is the most developed and is structured around five main group of factors that are taken into account:

- Global economy factors represent the key economic developments driving the demand for air transport.
- Factors characterising the passengers and their travel preferences change patterns in travel demand and travel destinations.
- Price of tickets set by the airlines to cover their operating costs influences passengers’ travel decisions and their choice of transport.
- More hub-and-spoke or point-to-point networks may alter the number of connections and flights needed to travel from origin to destination.
- Market structure describes size of aircraft used to satisfy the passenger demand (modelled via the Aircraft Assignment Tool).

3.29 Table 3 below presents a summary of the social, economic and air traffic related characteristics of three different scenarios developed by EUROCONTROL. The year 2016 served as the baseline year of the 20-year forecast results[4] (published in 2018 by EUROCONTROL). Historical data for the year 2019 are also shown later for reference.

---

[3] Prior to COVID-19 outbreak

[4] Challenges of Growth - Annex 1 - Flight Forecast to 2040, EUROCONTROL, September 2018

Table 3. Summary characteristics of EUROCONTROL scenarios.

	Global Growth	*Regulation and Growth*	*Fragmenting World*
2023 traffic growth	High ↗	Base →	Low ↘
Passenger Demographics (Population)	Ageing UN Medium-fertility variant	Ageing UN Medium-fertility variant	Ageing UN Zero-migration variant
Routes and Destinations	Long-haul ↗	No Change →	Long-haul ↘
Open Skies	EU enlargement later +Far & Middle East	EU enlargement Earliest	EU enlargement Latest
High-speed rail (new & improved connections)	20 city-pairs faster implementation	20 city-pairs	20 city-pairs later implementation.
Economic conditions			
GDP growth	Stronger ↗	Moderate →	Weaker ↘↘
EU Enlargement	+5 States, Later	+5 States, Earliest	+5 States, Latest
Free Trade	Global, faster	Limited, later	None
Price of travel Operating cost	Decreasing ↘↘	Decreasing ↘	No change →
Price of CO_2 in Emission Trading Scheme	Moderate	Lowest	Highest
Price of oil/barrel	Low	Lowest	High
Change in other charges	Noise: ↗ Security: ↘	Noise: ↗ Security: →	Noise: → Security: ↗
Structure Network	Hubs: Mid-East ↗↗ Europe ↘ Turkey↗ Point-to-point: N-Atlantic.↗↗	Hubs: Mid-East ↗↗ Europe & Turkey ↗ Point-to-point: N-Atlantic.↗	No change →
Market Structure	Industry fleet forecast + STATFOR assumptions	Industry fleet forecast + STATFOR assumptions	Industry fleet forecast + STATFOR assumptions

COVID-19 impact and extension to 2050

3.30 Since the start of 2020, COVID-19 has developed from a localised outbreak in China to the most severe global pandemic in a century. No part of European aviation is untouched by the human tragedy or the business crisis. This unprecedented crisis hindered air traffic growth in 2020: flight movements declined by 55% compared to 2019 at ECAC level. It continues to disrupt the traffic growth and patterns in Europe in 2021. In autumn 2020, EUROCONTROL published a medium-term forecast[5] to 2024, taking into account the impact of the COVID-19 outbreak. The latter is based on three different scenarios depending on how soon an effective vaccine would be made widely available to (air) travellers. Other factors have been included amongst

[5] Five-Year Forecast 2020-2024, IFR Movements, EUROCONTROL, November 2020.

which the economic impact of the crisis or levels of public confidence, to name a few. The Scenario 2: vaccine widely made available for travellers by Summer 2022, considered as the most likely, sees ECAC flights only reaching 92% of their 2019 levels in 2024.

3.31 In order to take into account the COVID-19 impact and to extend the horizon to 2050, the following adaptations have been brought to the original long-term forecast11. Considering the most-likely scenarios of the long-term forecast11 and the medium-term forecasted version of the long-term flight forecast has been derived:

a) Replace the long-term forecast11 horizon by the most recent medium-term forecast12 to account for COVID impact;

b) Update the rest of the horizon (2025-2040) assuming that the original growth rates of the long-term forecast11, would remain similar to those calculated pre COVID 19; and

c) Extrapolate the final years (2040-2050) considering the same average annual growth rates as the one forecasted for the 2035-2040 period, but with a 0.9 decay[6].

3.32 The method used relies on the calculation of adjustment factors at STATFOR[7] region-pair level and have been applied to the original long-term forecast11. Adjusting the baseline enables to further elaborate the baseline scenario as forecasted future fuel consumption and to 2030, 2040 and 2050, in the absence of action.

3.33 Figure 3 below shows the ECAC scenario of the passenger flight forecasted international departures for both historical (solid line) and future (dashed line) years.

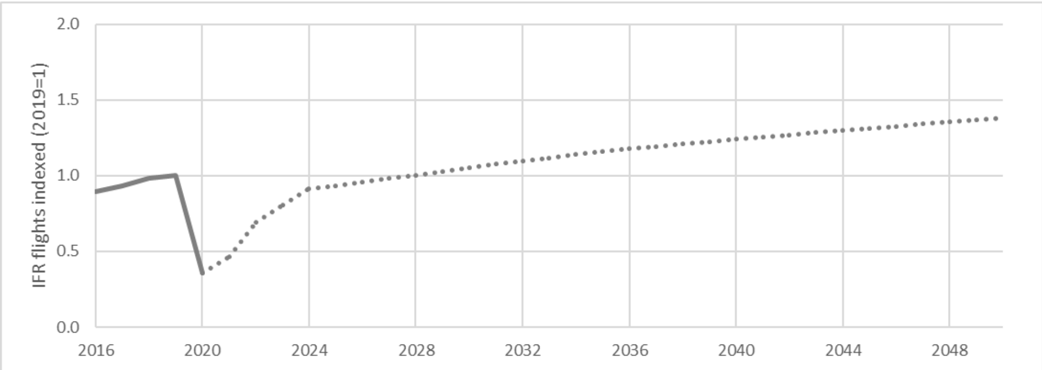


Figure 3: Updated EUROCONTROL "Regulation and Growth" scenario of the passenger flight forecast for ECAC international departures including the COVID-19 impact in 2020 and the following 4 years.

[6] As the number of flights has not been directly forecasted via the system but numerically extrapolated, it does not include any fleet renewal, neither network change (airport pairs) between 2040 and 2050. This factor is aimed at adjusting the extrapolation to capture the gradual maturity of the market.

[7] STATFOR (Statistics and Forecast Service) provides statistics and forecasts on air traffic in Europe and to monitor and analyse the evolution of the Air Transport Industry.

Further assumptions and results for the baseline scenario

3.34 The ECAC baseline scenario was generated by EUROCONTROL for all ECAC States. It covers all commercial international passenger flights departing[8] from ECAC airports, as forecasted in the aforementioned traffic scenario. The number of passengers per flight is derived from Eurostat data.

3.35 EUROCONTROL also generates a number of all-cargo flights in its baseline scenario. However, no information about the freight tonnes carried is available. Hence, historical and forecasted cargo traffic have been extracted from another source (ICAO[9]). This data, which is presented below, includes both belly cargo transported on passenger flights and freight transported on dedicated all-cargo flights.

3.36 Historical fuel burn and emission calculations are based on the actual flight plans from the PRISME[10] data warehouse used by EUROCONTROL, including the actual flight distance and the cruise altitude by airport pair. These calculations were made for about 99% of the passenger flights (the remaining flights had information missing in the flight plans). Determination of the fuel burn and CO_2 emissions for historical years is built up as the aggregation of fuel burn and emissions for each aircraft of the associated traffic sample characteristics. Fuel burn and CO_2 emission results consider each aircraft's fuel burn in its ground and airborne phases of flight and are obtained by use of the EUROCONTROL IMPACT[11] environmental model, with the aircraft technology level of each year.

3.37 Forecast years (until 2050) fuel burn and modelling calculations use the 2019 flight plan characteristics as much as possible, to replicate actual flown distances and cruise levels, by airport pairs and aircraft types. When not possible, this modelling approach uses past years traffics too, and, if needed, the ICAO CAEP forecast modelling. The forecast fuel burn and CO_2 emissions of the baseline scenario for forecast years uses the technology level of 2019.

3.38 For each reported year, the revenue per passenger kilometre (RPK) calculations use the number of passengers carried for each airport pair multiplied by the great circle distance between the associated airports and expressed in kilometres. Because of the coverage of the passenger estimation data sets (Scheduled, Low-cost, Non-Scheduled flights, available passenger information, etc.) these results are determined for about 99% of the historical passenger traffic, and 97% of the passenger flight forecasts. From the RPK values, the passenger flights RTK were calculated as the number of tonnes carried by kilometers, assuming that 1 passenger corresponds to 0.1 tonne.

3.39 The fuel efficiency represents the amount of fuel burn divided by the RPK for each available airport pair with passenger data, for the passenger traffic only. Here, the RPK and fuel efficiency results corresponds to the aggregation of these values for the whole concerned traffic years.

---

[8] International departures only. Domestic flights are excluded. A domestic is any flight between two airports in the State, regardless of the operator or which airspaces they enter en-route. Airports located overseas are attached to the State having the sovereignty of the territory. For example, France domestic include flights to Guadeloupe, Martinique, etc.

[9] ICAO Long-Term Traffic Forecasts, Passenger and Cargo, July 2016. Cargo forecasts have not been updated as new ICAO forecast including COVID-19 effects will be made available after the end of June 2021, so those cannot be considered in this action plan common section.

[10] PRISME is the name of the EUROCONTROL data warehouse hosting the flight plans, fleet and airframe data.

[11] https://www.eurocontrol.int/platform/integrated-aircraft-noise-and-emissions-modelling-platform

3.40 The following tables and figures show the results for this baseline scenario, which is intended to serve as a reference case by approximating fuel consumption and CO_2 emissions of European aviation in the absence of mitigation actions.

Table 4. Baseline forecast for international traffic departing from ECAC airports

Year	Passenger Traffic (IFR movements) (million)	Revenue Passenger Kilometres[12] RPK (billion)	All-Cargo Traffic (IFR movements) (million)	Freight Tonne Kilometres transported[13] FTKT (billion)	Total Revenue Tonne Kilometres[14] RTK (billion)
2010	4.56	1,114	0.198	45.4	156.8
2019	5.95	1,856	0.203	49.0	234.6
2030	5.98	1,993	0.348	63.8	263.1
2040	7.22	2,446	0.450	79.4	324.0
2050	8.07	2,745	0.572	101.6	376.1

Table 5. Fuel burn and CO_2 emissions forecast for the baseline scenario

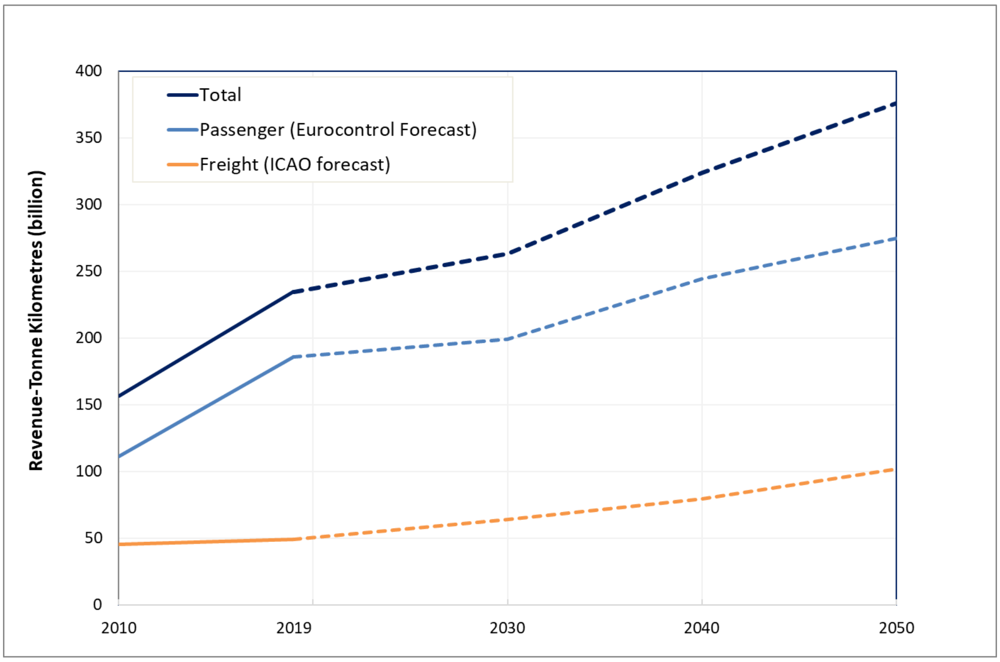
Year	Fuel Consumption (10^9 kg)	CO_2 emissions (10^9 kg)	Fuel efficiency (kg/RPK[12])	Fuel efficiency (kg/RTK[14])
2010	36.95	116.78	0.0332	0.332
2019	52.01	164.35	0.0280	0.280
2030	50.72	160.29	0.0252	0.252
2040	62.38	197.13	0.0252	0.252
2050	69.42	219.35	0.0250	0.250
For reasons of data availability, results shown in this table do not include cargo/freight traffic.				

[12] Calculated on the basis of Great Circle Distance (GCD) between airports, for 97% of the passenger traffic for forecast years.

[13] Includes passenger and freight transport (on all-cargo and passenger flights).

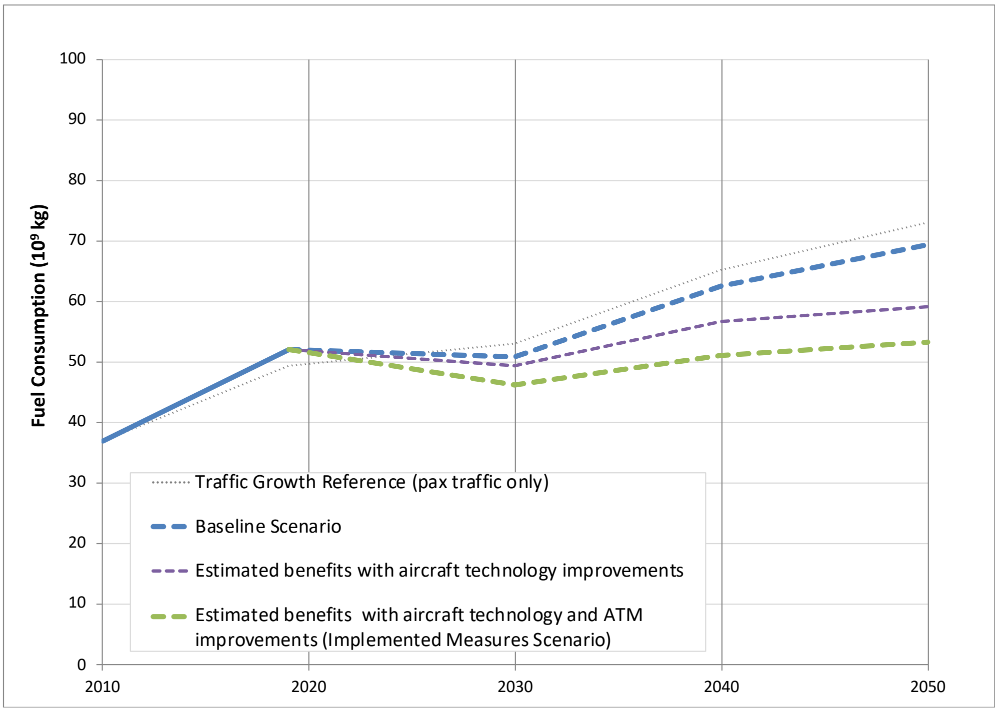
[14] A value of 100 kg has been used as the average mass of a passenger incl. baggage (ref: ICAO).

Figure 4. Forecasted traffic until 2050 (assumed both for the baseline and implemented measures scenarios).



3.41 The impact of the COVID-19 in 2020 is not fully reflected in Figure 4, as this representation is oversimplified through a straight line between 2019 and 2030. The same remark applies for Figure 5 and Figure 6.

Figure 5. Fuel consumption forecast for the baseline and implemented measures scenarios (international passenger flights departing from ECAC airports).



ECAC Scenario with Implemented Measures: Estimated Benefits

3.42 In order to improve the fuel efficiency and to reduce future air traffic emissions beyond the projections in the baseline scenario, ECAC States have taken further action. Assumptions for a top-down assessment of effects of mitigation actions are presented here, based on modelling results by EUROCONTROL and EASA. Measures to reduce aviation's fuel consumption and emissions will be described in the following chapters.

3.43 For reasons of simplicity, the scenario with implemented measures is based on the same traffic volumes as the baseline case, i.e. updated EUROCONTROL's 'Regulation and Growth' scenario described earlier. Unlike in the baseline scenario, the effects of aircraft related technology development and improvements in ATM/operations are considered here for a projection of fuel consumption and CO_2 emissions up to the year 2050.

3.44 Effects of improved aircraft technology are captured by simulating fleet roll-over and considering the fuel efficiency improvements of new aircraft types of the latest generation (e.g. Airbus A320NEO, Boeing 737MAX, Airbus A350XWB etc.). The simulated future fleet of aircraft has been generated using the Aircraft Assignment Tool[15] (AAT) developed collaboratively by EUROCONTROL, EASA and the European Commission. The retirement process of AAT is performed year by year, allowing the determination of the number of new aircraft required each year. In addition to the fleet rollover, a constant annual improvement of fuel efficiency of 1.16% per annum is assumed for each aircraft type with entry into service from 2020 onwards. This rate of improvement corresponds to the 'Advanced' fuel technology scenario used by CAEP to generate the fuel trends for the Assembly. This technology improvement modelling is applied to the years 2030 and 2040. For the year 2050, as the forecast traffic reuses exactly the fleet of the year 2040, the technological improvement is determined with the extrapolation of the fuel burn ratio between the baseline scenario and the technological improvement scenario results of the years 2030 to 2040.

3.45 The effects of improved ATM efficiency are captured in the Implemented Measures Scenario on the basis of efficiency analyses from the SESAR project. In SESAR, a value of 5,280 kg of fuel per flight for ECAC (including oceanic region) is used as a baseline[16]. Based on the information provided by the PAGAR 2019 document[17], and compared to a 2012 baseline, the benefits at the end of Wave 1 could be about 3% CO_2/fuel savings achieved by 2025 equivalent to 147.4 kg of fuel/flight. So far, the target for Wave 2 remains at about 7% more CO_2/fuel savings (352.6 kg of fuel) to reach the initial Ambition target of about 10% CO_2/fuel savings (500 kg fuel) per flight by 2035. The 2030 efficiency improvement is calculated by assuming a linear evolution between 2025 and 2035. As beyond 2035, there is no SESAR Ambition yet, it is assumed that the ATM efficiency improvements are reported extensively for years 2040 and 2050.

3.46 The as yet un-estimated benefits of Exploratory Research projects[18] are expected to increase the overall future fuel savings.

3.47 While the effects of introduction of Sustainable Aviation Fuels (SAF) were modelled in previous updates on the basis of the European ACARE goals[19], the expected SAF

---

[15] https://www.easa.europa.eu/domains/environment/impact-assessment-tools
[16] See SESAR ATM Master Plan – Edition 2020 (www.atmmasterplan.eu) - eATM.
[17] See SESAR Performance Assessment Gap Analysis Report (PAGAR) updated version of 2019 v00.01.04, 31-03-2021.
[18] See SESAR Exploratory Research projects - https://www.sesarju.eu/exploratoryresearch
[19] https://www.acare4europe.org/sria/flightpath-2050-goals/protecting-environment-and-energy-supply-0

supply objectives for 2020 were not met, and in the current update the SAF benefits have not been modelled as a European common measure in the implemented measures scenario. However, numerous initiatives related to SAF (e.g. ReFuelEU Aviation) are largely described in Section B chapter 2 and it is expected that future updates will include an assessment of its benefits as a collective measure.

3.48 Effects on aviation's CO_2 emissions of market-based measures including the EU Emissions Trading System (ETS) with the linked Swiss ETS, the UK ETS and the ICAO's Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA) have not been modelled in the top-down assessment of the implemented measures scenario presented here as, at the time of the submission of this action plan, a legislative proposal for the revision of the EU ETS Directive concerning aviation, is under development to complete the implementation of CORSIA by the EU and to strengthen the ambition level of the EU ETS. CORSIA is not considered a European measure but a global one. It aims for carbon-neutral growth (CNG) of aviation as compared to the average of 2019 and 2020 levels of emissions in participating States, and an indication of a corresponding (hypothetical) target applied to Europe is shown in Figure 6[20], while recalling that this is just a reference level, given that CORSIA was designed to contribute to the CNG 2020 globally and not in individual States or regions.

3.49 Tables 6-8 and Figure 6 summarise the results for the scenario with implemented measures. It should be noted that Table 6 show direct combustion emissions of CO_2 (assuming 3.16 kg CO^2 per kg fuel). More detailed tabulated results are found in Appendix A, including results expressed in equivalent CO_2 emissions on a well-to-wake basis (for comparison purposes of SAF benefits).

Table 6. Fuel burn and CO_2 emissions forecast for the Implemented Measures Scenario (new aircraft technology and ATM improvements only).

Year	Fuel Consumption (10^9 kg)	CO_2 emissions (10^9 kg)	Fuel efficiency (kg/RPK[21])	Fuel efficiency (kg/RTK[17])
2010	36.95	116.78	0.0332	0.332
2019	52.01	164.35	0.0280	0.280
2030	46.16	145.86	0.0229	0.229
2040	51.06	161.35	0.0206	0.206
2050	53.18	168.05	0.0192	0.192
2050 vs 2019			*-32%*	
For reasons of data availability, results shown in this table do not include cargo/freight traffic.				

[20] Note that in a strict sense the CORSIA target of CNG is aimed to be achieved globally (and hence not necessarily in each world region).
[21] Calculated on the basis of Great Circle Distance (GCD) between airports, for 97% of the passenger traffic for forecast years.

Table 7. Average annual fuel efficiency improvement for the Implemented Measures Scenario (new aircraft technology and ATM improvements only)

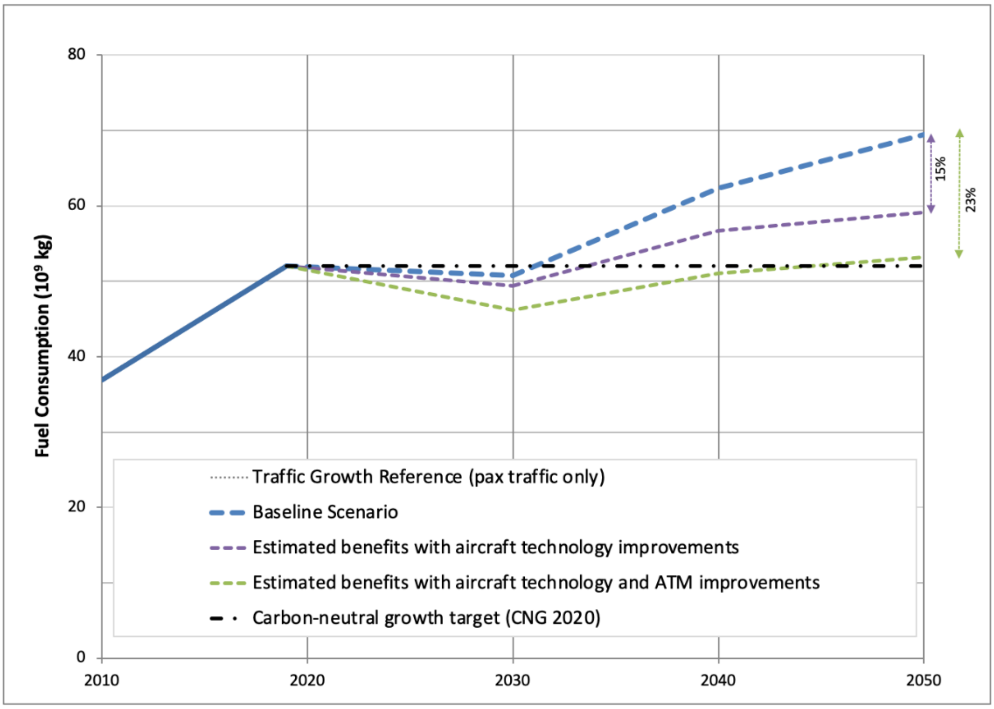
Period	Average annual fuel efficiency improvement (%)
2010-2019	-1.86%
2019-2030	-1.82%
2030-2040	-1.03%
2040-2050	-0.74%

Table 8. CO_2 emissions forecast for the scenarios described in this chapter.

Year	CO_2 emissions (10^9 kg)			% improvement by Implemented Measures (full scope)
	Baseline Scenario	Implemented Measures Scenario		
		Aircraft techn. improvements only	Aircraft techn. and ATM improvements	
2010	116,78			NA
2019	164,35			NA
2030	160,3	156,0	145,9	-9%
2040	197,1	179,3	161,4	-18%
2050	219,4	186,7	168,0	-23%

For reasons of data availability, results shown in this table do not include cargo/freight traffic. Note that fuel consumption is assumed to be unaffected by the use of sustainable aviation fuels.

Figure 6. Fuel consumption forecast for the baseline and implemented measures scenarios.



3.50 As shown in Figure 6, the impact of improved aircraft technology indicates an overall 15% reduction of fuel consumption and CO_2 emissions in 2050 compared to the baseline scenario. Overall CO_2 emissions, including the effects of new aircraft types and ATM-related measures, are projected to improve to lead to a 23% reduction in 2050 compared to the baseline.

3.51 From Table 6, under the currently assumed aircraft technology and ATM improvement scenarios, the fuel efficiency is projected to lead to a 32% reduction from 2019 to 2050. Indeed, the annual rate of fuel efficiency improvement is expected to progressively slowdown from a rate of 1.82% between 2019 and 2030 to a rate of 0.74% between 2040 and 2050. Aircraft technology and ATM improvements alone will not be sufficient to meet the post-2020 carbon neutral growth objective of ICAO. This confirms that additional action, particularly market-based measures and SAF, are required to fill the gap. There are among the ECAC Member States additional ambitious climate strategies where carbon neutrality by 2050 is set as the overall objective. The aviation sector will have to contribute to this objective.

4. Actions taken collectively throughout Europe

Technology and standards

Aircraft emissions standards

4.1 European Member States fully support ICAO's Committee on Aviation Environmental Protection (CAEP) work on the development and update of aircraft emissions standards, in particular to the ICAO Aircraft CO_2 Standard adopted by ICAO in 2017. Europe significantly contributed to its development, notably through the European Aviation Safety Agency (EASA). It is fully committed to its implementation in Europe and the need to review the standard on a regular basis in light of developments in aeroplane fuel efficiency. EASA has supported the process to integrate this standard into European legislation (2018/1139) with an applicability date of 1 January 2020 for new aeroplane types.

ASSESSMENT

4.2 This is a European contribution to a global measure (CO_2 standard). Its contribution to the global aspirational goals are available in CAEP.

Research and development

Clean Sky

The UK was a member of the European Union until the 31 January 2020, contributing to the work of Clean Sky during this time.

4.3 Clean Sky[22] is an EU Joint Undertaking that aims to develop and mature breakthrough "clean technologies" for air transport globally. Joint Undertakings are Public Private Partnership set up by the European Union on the EU research programmes. By accelerating their deployment, the Joint Undertaking will contribute to Europe's strategic environmental and social priorities, and simultaneously promote competitiveness and sustainable economic growth. The first Clean Sky Joint Undertaking (Clean Sky 1 - 2011-2017) had a budget of €1.6 billion, equally shared between the European Commission and the aeronautics industry. It aimed to develop environmental-friendly technologies impacting all flying-segments of commercial aviation. The objectives were to reduce aircraft CO_2 emissions by 20-40%, NO_x by around 60% and noise by up to 10dB compared to year 2000 aircraft.

4.4 This was followed up with a second Joint Undertaking (Clean Sky 2 – 2014-2024) with the objective to reduce aircraft emissions and noise by 20 to 30% with respect to the latest technologies entering into service in 2014. The current budget for the programme is approximately €4 billion.

[22] http://www.cleansky.eu/

4.5 The two Interim Evaluations of Clean Sky in 2011 and 2013 acknowledged that the programme is successfully stimulating developments towards environmental targets. These preliminary assessments confirm the capability of achieving the overall targets at completion of the programme.

4.6 Main remaining areas for Research and Technological Development (RTD) efforts under Clean Sky 2 were:

- Large Passenger Aircraft: demonstration of best technologies to achieve the environmental goals whilst fulfilling future market needs and improving the competitiveness of future products.
- Regional Aircraft: demonstrating and validating key technologies that will enable a 90-seat class turboprop aircraft to deliver breakthrough economic and environmental performance and a superior passenger experience.
- Fast Rotorcraft: demonstrating new rotorcraft concepts (tilt-rotor and compound helicopters) technologies to deliver superior vehicle versatility and performance.
- Airframe: demonstrating the benefits of advanced and innovative airframe structures (like a more efficient wing with natural laminar flow, optimised control surfaces, control systems and embedded systems, highly integrated in metallic and advanced composites structures). In addition, novel engine integration strategies and innovative fuselage structures will be investigated and tested.
- Engines: validating advanced and more radical engine architectures.
- Systems: demonstrating the advantages of applying new technologies in major areas such as power management, cockpit, wing, landing gear, to address the needs of a future generation of aircraft in terms of maturation, demonstration and Innovation.
- Small Air Transport: demonstrating the advantages of applying key technologies on small aircraft demonstrators to revitalise an important segment of the aeronautics sector that can bring new key mobility solutions.
- Eco-Design: coordinating research geared towards high eco-compliance in air vehicles over their product life and heightening the stewardship with intelligent Re-use, Recycling and advanced services.

4.7 In addition, the Clean Sky Technology Evaluator[23] will continue to be upgraded to assess technological progress routinely and evaluate the performance potential of Clean Sky 2 technologies at both vehicle and aggregate levels (airports and air traffic systems).

Disruptive aircraft technological innovations: European Partnership for Clean Aviation

As a member of the European Union until 31 January 2020, the UK actively participated in the Horizon 2020 programme. Since January 2021 the UK has been an associate country to Horizon Europe.

4.8 With the Horizon 2020 programme coming to a close in 2020, the Commission has adopted a proposal to set up a new Joint Undertaking under the Horizon Europe

[23] https://www.cleansky.eu/technology-evaluator-te

programme (2021-2027). The European Partnership for Clean Aviation (EPCA)[24] will follow in the footsteps of CleanSky2. The EU contribution proposed is again €1.7 billion. The stakeholder community has already formulated a Strategic Research and Innovation Agenda (SRIA), which is intended to serve as a basis of the partnership once established. Subject to the final provisions of the partnership and the EU budget allocation, industry stakeholders have proposed a commitment of €3 billion from the private side.

4.9 General objectives of EPCA:

a) To contribute to reduce the ecological footprint of aviation by accelerating the development of climate neutral aviation technologies for earliest possible deployment, therefore significantly contributing to the achievement of the general goals of the European Green Deal, in particular in relation to the reduction of Union-wide net greenhouse gas emissions reduction target of at least 55% by 2030, compared to 1990 levels and a pathway towards reaching climate neutrality by 2050.

b) To ensure that aeronautics-related research and innovation activities contribute to the global sustainable competitiveness of the Union aviation industry, and to ensure that climate-neutral aviation technologies meet the relevant aviation safety requirements, and remains a secure, reliable, cost-effective, and efficient means of passenger and freight transportation.

4.10 Specific objectives:

a) To integrate and demonstrate disruptive aircraft technological innovations able to decrease net emissions of greenhouse gasses by no less than 30% by 2030, compared to 2020 state-of-the-art technology while paving the ground towards climate-neutral aviation by 2050.

b) To ensure that the technological and the potential industrial readiness of innovations can support the launch of disruptive new products and services by 2035, with the aim of replacing 75% of the operating fleet by 2050 and developing an innovative, reliable, safe and cost-effective European aviation system that is able to meet the objective of climate neutrality by 2050.

c) To expand and foster integration of the climate-neutral aviation research and innovations value chains, including academia, research organisations, industry, and SMEs, also by benefitting from exploiting synergies with other national and European related programmes.

ASSESSMENT

4.11 The quantitative assessment of the technology improvement scenario from 2020 to 2050 has been calculated by EUROCONTROL and EASA and it is included in the section above (ECAC Baseline Scenario and Estimated Benefits of Implemented Measures) and in Appendix A.

[24] https://clean-aviation.eu/

Table 7 Fuel consumption and CO_2 emissions of international passenger traffic departing from ECAC airports, with aircraft technology improvements after 2019 included:

Year	Fuel Consumption (10^9 kg)	CO_2 emissions (10^9 kg)	Well-to-wake CO_2e emissions (10^9 kg)	Fuel efficiency (kg/RPK)	Fuel efficiency (kg/RTK)
2010	36.95	116.78	143.38	0.0332	0.332
2019	52.01	164.35	201.80	0.0280	0.280
2030	49.37	156.00	191.54	0.0232	0.232
2040	56.74	179.28	220.13	0.0217	0.217
2050	59.09	186.72	229.26	0.0202	0.202
For reasons of data availability, results shown in this table do not include cargo/freight traffic.					

Table 8 Average annual fuel efficiency improvement for the Implemented Measures Scenario (new aircraft technology only):

Period	Average annual fuel efficiency improvement (%)
2010-2019	-1.86%
2019-2030	-1.22%
2030-2040	-0.65%
2040-2050	-0.74%

Sustainable Aviation Fuels

4.12 Sustainable aviation fuels (SAF) including advanced biofuels and synthetic fuels, have the potential to significantly reduce aircraft emissions and ECAC States are embracing their large-scale introduction in line with the 2050 ICAO Vision.

4.13 The European collective SAF measures included in this Action Plan focus on their CO_2 reductions benefits. Nevertheless, SAF has the additional benefit of reducing air pollutant emissions of non-volatile Particulate Matter (nvPM) with up to 90% and sulphur (SO_X) with 100%, compared to fossil jet fuel[25]. As a result, the large-scale use of SAF can have important other non-CO_2 benefits on the climate which are not specifically assessed within the scope of this Plan.

ICAO standards applicable to SAF supply

4.14 Europe is actively contributing to the development of the ICAO CORSIA Standards and Recommended Practices (SARPs), though the ICAO Committee on Aviation and Environmental Protection (CAEP), establishing global Sustainability Requirements applicable to SAF as well as to the CORSIA Methodology for Calculating Actual Life Cycle Emissions Values and to the calculation of CORSIA Default Life Cycle Emissions Values for CORSIA Eligible Fuels; CORSIA standards are applicable to any SAF use to be claimed under CORSIA in order to reduce offsetting obligations by aeroplane operators.

[25] ICAO 2016 Environmental Report, Chapter 4, Page 162, Figure 4.

ASSESSMENT

4.15 The inclusion of European requirements for SAF respond to ICAO Guidance (Doc 9988) request (Para. 4.2.14) to provide estimates of the actual life cycle emissions of the SAF which are being used or planned to deploy and the methodology used for the life cycle analysis. It is therefore provided for information purposes only and no further assessment of its benefits in terms of reduction in aviation emissions is provided in this action plan common section.

Analysis of the impact of some UK SAF uptake is considered in Chapter 6.

Projects funded under the European Union's Horizon 2020 research and innovation programme

4.16 Since 2016, seven new projects have been funded by the Horizon 2020, which is the biggest Research and Innovation program of the EU.

4.17 **BIO4A**[26]: The "Advanced Sustainable Biofuels for Aviation» project plan to demonstrate the first large industrial-scale production and use of SAF in Europe obtained from residual lipids such as Used Cooking Oil.

4.18 The project will also investigate the supply of sustainable feedstocks produced from drought-resistant crops such as Camelina, grown on marginal land in EU Mediterranean areas. By adopting a combination of biochar and other soil amendments, it will be possible to increase the fertility of the soil and its resilience to climate change, while at the same time storing fixed carbon into the soil.

4.19 BIO4A will also test the use of SAF across the entire logistic chain at industrial scale and under market conditions, and it will finally assess the environmental and socio-economic sustainability performance of the whole value chain.

4.20 Started in May 2018, BIO4A will last until 2022, and it is carried out by a consortium of seven partners from five European countries.

4.21 **KEROGREEN[27]**: Production of sustainable aircraft grade kerosene from water and air powered by renewable electricity, through the splitting of CO_2, syngas formation and Fischer-Tropsch synthesis (KEROGREEN), is a Research and Innovation Action (RIA) carried out by six partners from four European countries aiming at the development and testing of an innovative conversion route for the production of SAF from water and air powered by renewable electricity.

4.22 The new approach and process of KEROGREEN reduces overall CO_2 emission by creating a closed carbon fuel cycle and at the same time creates long-term large-scale energy storage capacity which will strengthen the EU energy security and allow creation of a sustainable transportation sector.

4.23 The KEROGREEN project expected duration is from April 2018 to March 2022.

4.24 **FlexJET[28]**: Sustainable Jet Fuel from Flexible Waste Biomass (flexJET) is a four-year project targeting diversifying the feedstock for SAF beyond vegetable oils and fats to biocrude oil produced from a wide range of organic waste. This is also one of the first technologies to use green hydrogen from the processed waste feedstock for the downstream refining process thereby maximising greenhouse gas savings.

[26] www.bio4a.eu
[27] www.kerogreen.eu
[28] www.flexjetproject.eu

4.25 The project aims at building a demonstration plant for a 12 t/day use of food & market waste and 4000 l/day of Used Cooking Oil (UCO), produce hydrogen for refining through separation from syngas based on Pressure Swing Absorption technology, and finally deliver 1200 tons of SAF (ASTM D7566 Annex 2) for commercial flights to British Airways.

4.26 The consortium with 13 partner organisations has brought together some of the leading researchers, industrial technology providers and renewable energy experts from across Europe. The project has a total duration of 48 months from April 2018 to March 2022.

4.27 **BioSFerA**[29]: The Biofuels production from Syngas Fermentation for Aviation and maritime use (BioSFerA)project, aims to validate a combined thermochemical - biochemical pathway to develop cost-effective interdisciplinary technology to produce sustainable aviation and maritime fuels. At the end of the project next generation aviation and maritime biofuels, completely derived from second generation biomass, will be produced and validated by industrial partners at pilot scale. The project will undertake a full value chain evaluation that will result in a final analysis to define a pathway for the market introduction of the project concept. Some crosscutting evaluations carried out on all tested and validated processes will complete the results of the project from an economic, environmental and social point of view. The project is carried out by a consortium of 11 partners from 6 European countries and its expected duration is from 1 April 2020 to 31 March 2024.

4.28 **BL2F**[30]: The Black Liquor to Fuel (BL2F) project will use “Black Liquor” to create a clean, high-quality biofuel. Black liquor is a side-stream of the chemical pulping industry that can be transformed into fuel, reducing waste and providing an alternative to fossil fuels. Launched in April 2020, BL2F will develop a first-of-its-kind Integrated “Hydrothermal Liquefaction” (HTL) process at pulp mills, decreasing carbon emissions during the creation of the fuel intermediate. This will then be further upgraded at oil refineries to bring it closer to the final products and provide a feedstock for marine and aviation fuels.

4.29 BL2F aims to contribute to a reduction of 83% CO_2 emitted compared to fossil fuels. A large deployment of the processes developed by BL2F, using a variety of biomass, could yield more than 50 billion litres of advanced biofuels by 2050. The project brings together 12 partners from 8 countries around Europe and its expected duration is from 1 April 2020 till 31 March 2023.

4.30 **FLITE**[31]: The Fuel via Low Carbon Integrated Technology from Ethanol (FLITE) consortium proposes to expand the supply of low carbon jet fuel in Europe by designing, building, and demonstrating an innovative ethanol-based Alcohol-to-Jet (ATJ) technology in an ATJ Advanced Production Unit (ATJ-APU). The ATJ-APU will produce jet blend stocks from non-food/non-feed ethanol with over 70% GHG reductions relative to conventional jet. The Project will demonstrate over 1000 hours of operations and production of over 30,000 metric tonnes of Sustainable Aviation Fuel.

---

[29] https://biosfera-project.eu
[30] https://www.bl2f.eu
[31] https://cordis.europa.eu/project/id/857839

4.31 The diversity of ethanol sources offers the potential to produce cost competitive SAF, accelerating uptake by commercial airlines and paving the way for implementation. The project is carried out by a consortium of five partners from six European countries and its expected duration is from 1 December 2020 till 30 November 2024.

4.32 **TAKE-OFF**[32]: Is an industrially driven project aiming to be a game-changer in the cost-effective production of SAF from CO_2 and hydrogen. The unique TAKE-OFF technology is based on conversion of CO_2 and H_2 to SAF via ethylene as intermediate. Its industrial partners will team up with research groups to deliver a highly innovative process which produces SAF at lower costs, higher energy efficiency and higher carbon efficiency to the crude jet fuel product than the current benchmark Fischer-Tropsch process. TAKE-OFF's key industrial players should allow the demonstration of the full technology chain, utilising industrial captured CO_2 and electrolytically produced hydrogen. The demonstration activities will provide valuable data for comprehensive technical and economic and environmental analyses with an outlook on Chemical Factories of the Future. The project is carried out by a consortium of nine partners from five European countries and its expected duration is from 1 January 2021 till 24 December 2024.

ASSESSMENT

4.33 This information on SAF European Research and Development projects are included in this common section of the action plan to complement the information on Sustainable Aviation Fuels measures and to inform on collective European efforts. No further quantitative assessment of the benefits of this collective European measure in terms of reduction in aviation emissions is provided in the common section of this action plan.

Operational Improvements

The EU's Single European Sky Initiative and SESAR

SESAR Project

The UK as an associated country to Horizon Europe, continues to play a role the Single European Sky ATM Research (SESAR)

4.34 The European Union's Single European Sky (SES) policy aims to reform Air Traffic Management (ATM) in Europe in order to enhance its performance in terms of its capacity to manage variable volumes of flights in a safer, more cost-efficient and environmentally friendly manner.

4.35 The SESAR (Single European Sky ATM Research) programme addresses the technological dimension of the single European sky, aiming in particular to deploy a modern, interoperable and high-performing ATM infrastructure in Europe. SESAR contributes to the Single Sky's performance targets by defining, validating and deploying innovative technological and operational solutions for managing air traffic in a more efficient manner. SESAR coordinates and concentrates all EU research and development (RTD) activities in ATM.

4.36 SESAR is fully aligned with the Union's objectives of a sustainable and digitalised mobility and is projected towards their progressive achievement over the next decade. To implement the SESAR project, the Commission has set up with the

[32] https://cordis.europa.eu/project/id/101006799

industry, an innovation cycle comprising three interrelated phases: definition, development and deployment. These phases are driven by partnerships (SESAR Joint Undertaking and SESAR Deployment Manager) involving all categories of ATM/aviation stakeholders.

4.37 Guided by the European ATM Master Plan, the SESAR Joint Undertaking (SJU) is responsible for defining, developing, validating and delivering technical and operation solutions to modernise Europe's ATM system and deliver benefits to Europe and its citizens. The SESAR JU research programme is developed over successive phases, SESAR 1 (from 2008 to 2016) and SESAR 2020 (started in 2016) and SESAR 3 (starting in 2022). It is delivering SESAR solutions in four key areas, namely airport operations, network operations, air traffic services and technology enablers.

Results

4.38 To date, the SESAR JU has delivered over 90 solutions for implementation, many of which offer direct and indirect benefits for the environment, with more solutions in the pipeline in SESAR 2020. Outlined in the SESAR Solutions Catalogue, these include solutions such as wake turbulence separation (for arrivals and departure), optimised use of runway configuration for multiple runway airports, or even optimised integration of arrival and departure traffic flows for single and multiple runway airports. Looking ahead, it is anticipated that the next generation of SESAR solutions will contribute to a reduction of some 450 kg CO_2 per flight.

4.39 Considering the urgency of the situation, the SESAR JU is working to accelerate the digital transformation in order to support a swift transition to greener aviation. Large-scale demonstrators are key to bridging the industrialisation gap, bringing these innovations to scale and encouraging rapid implementation by industry. Such large-scale efforts have started now with the recently launched ALBATROSS project. They will also be the focus of the future SESAR 3 Joint Undertaking, which is expected to give further and fresh impetus to this important endeavour.

4.40 The Performance Ambitions for 2035 compared to a 2012 baseline for Controlled airspace for each key performance area are presented in the figure below, with the ambition for environment, expressed in CO_2 reduction, highlighted by the green dotted rectangle of Figure 7 below:

Figure 7: Performance Ambitions for 2035 for Controlled airspace (Source: European ATM Master Plan 2020 Edition).

Key performance area	SES high-level goals 2005	Key performance indicator	Performance ambition vs. baseline: Baseline value (2012)	Ambition value (2035)	Absolute improvement	Relative improvement
Capacity	Enable 3-fold increase in ATM capacity	**Departure delay**[4], min/dep	9.5 min	6.5-8.5 min	1-3 min	10-30%
		IFR movements at most congested airports[5], million	4 million	4.2-4.4 million	0.2-0.4 million	5-10%
		Network throughput IFR flights[5], million	9.7 million	~15.7 million	~6.0 million	~60%
		Network throughput IFR flight hours[5], million	15.2 million	~26.7 million	~11.5 million	~75%
Cost efficiency	Reduced ATM services unit costs by 50% or more	**Gate-to-gate direct ANS cost per flight**[1] - EUR(2012)	EUR 960	EUR 580-670	EUR 290-380	30-40%
Operational efficiency		**Gate-to-gate fuel burn per flight**[2], kg/flight	5280 kg	4780-5030 kg	250-500 kg	5-10%
		Additional gate-to-gate flight time per flight, min/flight	8.2 min	3.7-4.1 min	4.1-4.5 min	50-55%
		Within the: Gate-to-gate flight time per flight[3], min/flight	(111 min)	(116 min)		
Environment	Enable 10% reduction in the effects flights have on the environment	**Gate-to-gate CO_2 emissions**, tonnes/flight	16.6 tonnes	15-15.8 tonnes	0.8-1.6 tonnes	5-10%
Safety	Improve safety by factor 10	**Accidents with direct ATM contribution**[6], #/year Includes in-flight accidents as well as accidents during surface movement (during taxi and on the runway)	0.7 (long-term average)	no ATM related accidents	0.7	100%
Security		**ATM related security incidents resulting in traffic disruptions**	unknown	no significant disruption due to cyber-security vulnerabilities	unknown	-

1 Unit rate savings will be larger because the average number of Service Units per flight continues to increase.
2 "Additional" means the average flight time extension caused by ATM inefficiencies.
3 Average flight time increases because the number of long-distance flights is forecast to grow faster than the number of short-distance flights.
4 All primary and secondary (reactionary) delay, including ATM and non-ATM causes.
5 Includes all non-segregated unmanned traffic flying IFR, but not the drone traffic flying in airspace below 500 feet or the new entrants flying above FL 600
6 In accordance with the PRR definition: where at least one ATM event or item was judged to be DIRECTLY in the causal chain of events leading to the accident. Without that ATM event, it is considered that the accident would not have happened.

4.41 While all SESAR solutions bring added value to ATM performance, some have a higher potential to contribute the performance of the entire European ATM network and require a coordinated and synchronised deployment. To facilitate the deployment of these SESAR solutions, the Commission establishes common projects that mandate the synchronised implementation of selected essential ATM functionalities based on SESAR solutions developed and validated by the SESAR JU.

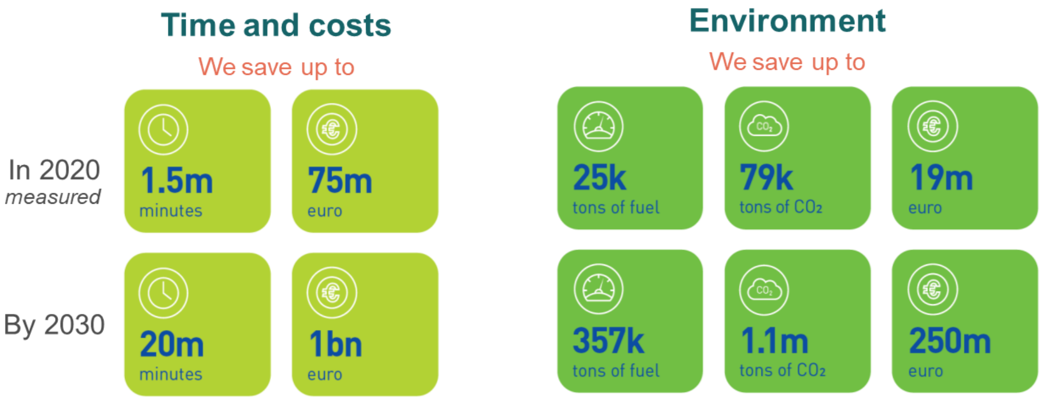
4.42 The first common project was launched in 2014 and its implementation is currently being coordinated by the SESAR Deployment Manager throughout the entire European ATM network. It includes six ATM functionalities aiming in particular to:

- Optimise the distancing of aircraft during landing and take-off, reducing delays and fuel burn while ensuring the safest flying conditions.
- Allow aircraft to fly their preferred and usually most fuel-efficient trajectory (free route).
- Implement an initial, yet fundamental step towards digitalising communications between aircraft and controllers and between ground stakeholders allowing better planning, predictability, thus less delays and fuel optimisation and passenger experience.

4.43 The first common project[33] is planned to be completed by 2027. However, the benefits highlighted in Figure 7 below have been measured where the functionalities have already been implemented.

Figure 7: First results of the first common project implemented.

[33] https://ec.europa.eu/transport/modes/air/sesar/deployment_en



SESAR Exploratory Research (V0 to V1)

4.44 SESAR Exploratory Research projects explore new concepts beyond those identified in the European ATM Master Plan or emerging technologies and methods. The knowledge acquired can be transferred into the SESAR industrial and demonstration activities. SESAR Exploratory Research projects are not subject to performance targets but should address the performances to which they have the potential to contribute.

SESAR Industrial Research & Validation Projects (environmental focus)

4.45 The main outcomes of the industrial research and validation projects dedicated to the environmental impacts of aviation in SESAR 1 were:

- The initial development by EUROCONTROL of the IMPACT[34] web-based platform which allows noise impact assessments and estimates of fuel burn and resulting emissions to be made from common inputs, thus enabling trade-offs to be conducted. IMPACT has since been continuously maintained and developed by EUROCONTROL, used for ICAO Committee on Aviation Environmental Protection Modelling and Database Group (CAEP) assessments, the conduct of studies in support of the European Aviation Environment Report (EAER) editions 2016 and 2019, and has been adopted by a large range of aviation stakeholders.
- The initial development/maintenance Open-ALAQS that provides a mean to perform emissions inventory at airports, emissions concentration calculation and dispersion.
- The development of an IMPACT assessment process[35].

4.46 It should be noted that these tools and methodology were developed to cover the research and the future deployment phase of SESAR, as well as to support European states and agencies in conducting environmental impact assessments for operational or regulatory purposes. They are still in use in SESAR. SESAR Industrial Research and Validation assesses and validates technical and operational concepts in simulated and real operational environments according to a set of key performance areas. These concepts mature through the SESAR programme from V1 to V3 to become SESAR Solutions ready for deployment. SESAR has a wide range of solutions to improve the efficiency of air traffic management, some of which are specifically designed to improve environmental performance, by reducing noise impact around airports and/or fuel consumption and emissions in all phases of flight.

---

[34] https://www.eurocontrol.int/platform/integrated-aircraft-noise-and-emissions-modelling-platform
[35] https://www.sesarju.eu/sites/default/files/documents/transversal/SESAR%202020%20-%20Environment%20Impact%20Assessment%20Guidance.pdf

4.47 A catalogue of SESAR Solutions is available[36] and those addressing environment impacts are identified by the following pictogram:

SESAR2020 Industrial Research and Validation - Environmental Performance Assessment

4.48 The systematic assessment of environmental impacts of aviation are at the heart of SESAR Industrial Research and Validation activities since SESAR 1, with a very challenging target on fuel/CO_2 efficiency of 500kg of fuel savings on average per flight.

4.49 SESAR Pj19.04 Content Integration members are monitoring the progress of SESAR Solutions towards this target in a document call Performance Assessment and Gap Analysis Report (PAGAR). The Updated version of PAGAR 2019 provides the following environmental achievements:

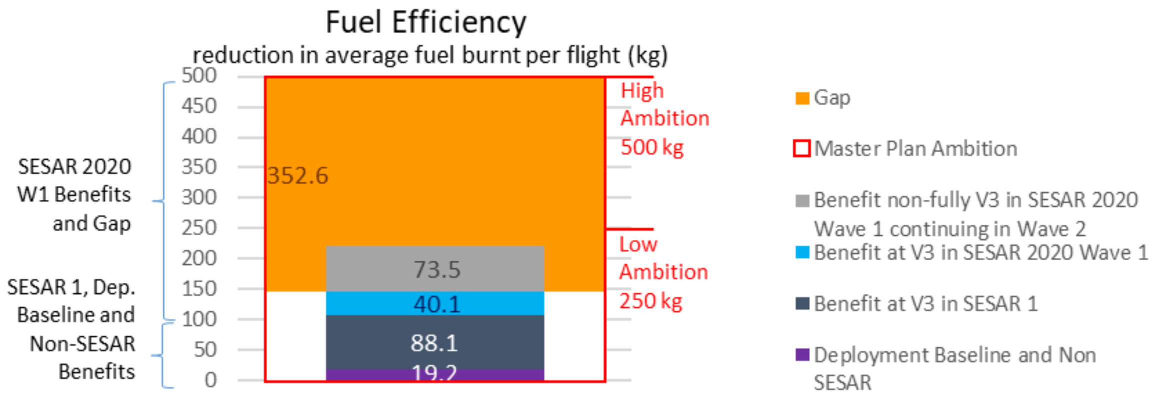


Figure 8: SESAR fuel efficiency achievement versus gap (Source: Updated version of PAGAR 2019)

4.50 The Fuel Efficiency benefits at V3 maturity level in SESAR 2020 Wave 1 represents an average of 40.1 kg of fuel savings per flight. There would therefore be a gap of 352.6 kg in fuel savings per flight to be filled by Wave 2, compared to the high fuel savings Ambition target (and a gap of 102.6 kg with respect to the low Ambition target, as the Master Plan defines a range of 5-10% as the goal). Potentially 73.5 kg might be fulfilled from Wave 1 Solutions non-fully V3 continuing in Wave 2.

4.51 A fuel saving of 40.1 kg per ECAC flight equates to about 0.76% of the 5,280kg of fuel burnt on average by an ECAC flight in 2012 (SESAR baseline). Although this might seem marginal, in 2035, ECAC-wide, it would equate to 1.9 million tonnes of CO_2 saved, equivalent to the CO_2 emitted by 165,000 Paris-Berlin flights; or a city of 258,000 European citizens; or the CO_2 captured by 95 million trees per year.

4.52 In SESAR, a value of 5,280 Kg of fuel per flight for the ECAC (including oceanic region) is used as a baseline[37]. Based on the information provided by the PAGAR 2019 document[38], the benefits at the end of Wave 1 could be about 3% CO_2/fuel savings achieved by 2025 equivalent to 147.4kg of fuel/flight. So far, the target for Wave 2 remains at about 7% more CO_2/fuel savings (352.6kg of fuel) to reach the

[36] https://www.sesarju.eu/news/sesar-solution-catalogue-third-edition-now-out
[37] See SESAR ATM Master Plan – Edition 2020 (www.atmmasterplan.eu) – eATM
[38] See SESAR Performance Assessment Gap Analysis Report (PAGAR) updated version of 2019 v00.01.04, 31-03-2021

initial Ambition target of about 10% CO_2/fuel savings (500kg fuel) per flight by 2035. Beyond 2035, there is no SESAR Ambition yet. To this could be added the as yet non-estimated benefits of Exploratory Research projects[39].

SESAR AIRE demonstration projects

4.53 In addition to its core activities, the SESAR JU co-financed projects where ATM stakeholders worked collaboratively to perform integrated flight trials and demonstrations of solutions. These aimed to reduce CO_2 emissions for surface, terminal, and oceanic operations and substantially accelerate the pace of change. Between 2009 and 2012, the SESAR JU co-financed a total of 33 “green” projects in collaboration with global partners, under the Atlantic Interoperability Initiative to Reduce Emissions (AIRE). AIRE[40] is the first large-scale environmental initiative bringing together aviation players from both sides of the Atlantic. So far, three AIRE cycles have been successfully completed.

4.54 A total of 15 767 flight trials were conducted, involving more than 100 stakeholders, demonstrating savings ranging from 20 to 1 000kg of fuel per flight (or 63 to 3150 kg of CO_2), and improvements in day-to-day operations. Another nine demonstration projects took place from 2012 to 2014, also focusing on the environment, and during 2015/2016 the SESAR JU co-financed fifteen additional large-scale demonstration projects, which were more ambitious in geographic scale and technology.

SESAR 2020 Very Large-Scale Demonstrations (VLDs)

4.55 VLDs evaluate SESAR Solutions on a much larger scale and in real operations to prove their applicability and encourage the early take-up of V3 mature solutions. SESAR JU has recently awarded ALBATROSS[41], a consortium of major European aviation stakeholder groups to demonstrate how the technical and operational R&D achievements of the past years can transform the current fuel intensive aviation to an environment-friendly industry sector.The ALBATROSS consortium will carry a series of demonstration flights, which the aim to implementing a “perfect flight” (in other words the most fuel-efficient flight) will be explored and extensively demonstrated in real conditions, through a series of live trials in various European operating environments. The demonstrations will span through a period of several months and will utilise over 1,000 demonstration flights.

Preparing SESAR

4.56 Complementing the European ATM Master Plan 2020 and the High-Level Partnership Proposal, the Strategic Research and Innovation Agenda (SRIA) details the research and innovation roadmaps to achieve the Digital European Sky, matching the ambitions of the ‘European Green Deal’ and the ‘Europe fit for the digital age’ initiative.

4.57 The SRIA[42] identifies inter-alia the need to continue working on “optimum green trajectories”, on non-CO_2 impacts of aviation, and the need to accelerate decarbonisation of aviation through operational and business incentivisation.

ASSESSMENT

4.58 The quantitative assessment of the operational and ATM improvement scenario from 2020 to 2050 has been included in the modelled scenarios by EUROCONTROL on

[39] See SESAR Exploratory Research projects - https://www.sesarju.eu/exploratoryresearch
[40] https://ec.europa.eu/transport/modes/air/environment/aire_en#:~:text=The%20joint%20initiative%20AIRE%20(Atlantic,NEXTGEN%20in%20the%20United%20States
[41] https://www.sesarju.eu/projects/ALBATROSS
[42] https://www.sesarju.eu/node/3697

the basis of efficiency analyses from the SESAR project indicated in Figure 8 above and it is included in Section A above (ECAC Baseline Scenario and Estimated Benefits of Implemented Measures).

Table 9. CO_2 emissions forecast for the ATM improvements scenarios.

Year	**CO_2 emissions (10^9 kg)**	
	Baseline Scenario	**Implemented Measures Scenario**
		ATM improvements
2030	160.29	149.9
2040	197.13	177.4
2050	210.35	197.4

For reasons of data availability, results shown in this table do not include cargo/freight traffic. Note that fuel consumption is assumed to be unaffected by the use of sustainable aviation fuels.

Market Based Measures

The Carbon Offsetting and Reduction Scheme for International Aviation

4.59 ECAC Member States have always been strong supporters of a market-based measure scheme for international aviation to incentivise and reward good investment and operational choices, and so welcomed the agreement on the Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA).

4.60 The 39th General Assembly of ICAO (2016) reaffirmed the 2013 objective of stabilising CO_2 emissions from international aviation at 2020 levels. In addition, the States adopted the introduction of a global market-based measure, namely the ‘Carbon Offsetting and Reduction Scheme for International Aviation’ (CORSIA), to offset and reduce international aviation’s CO_2 emissions above average 2019/2020 levels through standard international CO_2 emissions reductions units which would be put into the global market. This major achievement was most welcome by European States which have actively promoted the mitigation of international emissions from aviation at a global level.

Development and update of ICAO CORSIA standards

4.61 ECAC Member States have fully supported ICAO’s work on the development of Annex 16, Volume IV to the Convention on International Civil Aviation containing the Standards and Recommended Practices (SARPs) for the implementation of CORSIA, which was adopted by the ICAO Council in June 2018.

4.62 As a part of the ICAO’s Committee on Aviation Environmental Protection (CAEP) work programme for the CAEP/12 cycle, CAEP’s Working Group 4 (WG4) is tasked to maintain the Annex 16, Volume IV and related guidance material, and to propose revisions to improve those documents as needed.

4.63 Europe is contributing with significant resources to the work of CAEP-WG4 and EASA in particular by providing a WG4 co-Rapporteur, and by co-leading the WG4 task on maintaining the Annex 16, Volume IV and related guidance material.

ASSESSMENT

4.64 CORSIA is a global measure which assessment is undertaken globally by ICAO. Thus, the assessment of the benefits provided by CORSIA in terms of reduction in European emissions is not provided in this action plan.

The EU Emissions Trading System

The UK participated in the EU Emissions Trading System until 31 December 2020. The UK Emissions Trading Scheme (UK ETS) began operation on 1 January 2021, more information on the UK ETS can be found in Chapter 6.

4.65 The EU ETS began operation in 2005, for aviation in 2012; a series of important changes to the way it works took effect in 2013, strengthening the system. The EU ETS works on the "cap and trade" principle. This means there is a "cap", or limit, on the total amount of certain greenhouse gases that can be emitted by the factories, power plants, other installations and aircraft operators in the system. Within this cap, companies can sell to or buy emission allowances from one another. The limit on allowances available provides certainty that the environmental objective is achieved and gives allowances a market value.

4.66 For aviation, the cap is calculated based on the average emissions from the years 2004-2006, while the free allocation to aircraft operators is based on activity data from 2010. The cap for aviation activities for the 2013-2020 phase of the ETS was set to 95% of these historical aviation emissions. Starting from 2021, free allocation to aircraft operators is reduced by the linear reduction factor (currently of 2.2%) now applicable to all ETS sectors. Aircraft operators are entitled to free allocation based on a benchmark, but this does not cover the totality of emissions. The remaining allowances need to be purchased from auctions or from the secondary market. The system allows aircraft operators to use aviation allowances or general (stationary installations) allowances to cover their emissions. Currently, 82% of aviation allowances are distributed through free allocation, 3% are part of a special reserve for new entrants and fast growers, and 15% are auctioned. The legislation to include aviation in the EU ETS was adopted in 2008 by the European Parliament and the Council[43].

4.67 Following the 2013 ICAO agreement on developing CORSIA, the EU decided to limit the scope of the EU ETS to flights between airports located in the European Economic Area (EEA) for the period 2013-2016, and to carry out a new revision in the light of the outcome of the 2016 ICAO Assembly. The European Commission assessed the outcome of the 39th ICAO Assembly and, in that light, a new Regulation was adopted in 2017[44].

Impact on fuel consumption and/or CO_2 emissions

4.68 The EU ETS has delivered around 200 MT of CO_2 emission reductions between 2013 and 2020[45]. While the in-sector aviation emissions for intra-EEA flights kept growing, from 53,5 million tonnes CO_2 in 2013 to 69 million in 2019, the flexibility of the EU ETS, whereby aircraft operators may use any allowances to cover their emissions, meant that the CO_2 impacts from these flights did not lead to overall

[43] Directive 2008/101/EC of the European Parliament and of the Council of 19 November 2008 amending Directive 2003/87/EC so as to include aviation activities in the scheme for greenhouse gas emission allowance trading within the Community, http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32008L0101

[44] Decision No. 377/2013/EU derogating temporarily from Directive 2003/87/EC establishing a scheme for greenhouse gas emission allowance trading within the Community, http://eur-lex.europa.eu/LexUriServLexUriServ.do?uri=CELEX:32013D0377:EN:NOT

[45] See the 2019 European aviation environmental report: "Between 2013 and 2020, an estimated net saving of 193.4 Mt CO_2 (twice Belgium's annual emissions) will be achieved by aviation via the EU ETS through funding of emissions reduction in other sectors.", https://www.eurocontrol.int/publication/european-aviation-environmental-report-2019

greater greenhouse gas emissions. Verified emissions from aviation covered by the EU Emissions Trading System (ETS) in 2019 compared to 2018 continued to grow, albeit more modestly, with an increase of 1% compared to the previous year, or around 0.7 million tonnes CO_2 equivalent[46].

ASSESSMENT

A quantitative assessment of the EU Emissions Trading System benefits based on the current scope (intra-European flights) is shown in Table 10.

Table 10: Summary of estimated EU-ETS emission reductions

Estimated emissions reductions resulting from the EU-ETS[47]

Year	*Reduction in CO_2 emissions*
2013-2020	*~200 MT[48]*

Those benefits illustrate past achievements.

Additional Measures

ACI Airport Carbon Accreditation

4.69 Airport Carbon Accreditation is a certification programme for carbon management at airports, based on international carbon mapping and management standards, specifically designed for the airport industry. It was launched in 2009 by Airport Council International (ACI) EUROPE, the trade association for European airports. Since then, it has expanded globally and is today available to members of all ACI Regions.

4.70 This industry-driven initiative was officially endorsed by EUROCONTROL and the European Civil Aviation Conference (ECAC). The programme is overseen by an independent Advisory Board comprised of many distinguished, independent experts from the fields of aviation and environment, including the European Commission, ECAC, ICAO and the UNFCCC.

[46] https://ec.europa.eu/clima/news/carbon-market-report-emissions-eu-ets-stationary-installations-fall-over-9_en

[47] Include aggregated benefits of EU ETS and Swiss ETS for 2020.

[48] See the 2019 European aviation environmental report: "Between 2013 and 2020, an estimated net saving of 193.4 Mt CO_2 (twice Belgium's annual emissions) will be achieved by aviation via the EU ETS through funding of emissions reduction in other sectors.", https://www.eurocontrol.int/publication/european-aviation-environmental-report-2019

airport
carbon
accreditation
MAPPING I REDUCTION I OPTIMISATION I NEUTRALITY

4.71 The underlying aim of the programme is to encourage and enable airports to implement best practice carbon and energy management processes and to gain public recognition of their achievements. It requires airports to measure their CO_2 emissions in accordance with the World Resources Institute and World Business Council for Sustainable Development GHG Protocol and to get their emissions inventory assured by an independent third party.

4.72 In addition to the already existing four accreditation levels, in 2020 two new accreditation levels were introduced: Level 4 and Level 4+. The introduction of those two new levels aims on one hand to align the programme with the objectives of the Paris Agreement and on the other hand to give, especially to airports that have already reached a high level of carbon management maturity, the possibility to continue their improvements[49].

4.73 The six steps of the programme are shown in Figure 9 and are as follows: Level 1 "Mapping", Level 2 "Reduction", Level 3 "Optimisation", Level 3+ "Neutrality", Level 4 "Transformation" and Level 4+ "Transition".

Figure 9 Six steps of Airport Carbon Accreditation

[49] Interim Report 2019 – 2020, Airport Carbon Accreditation 2020

4.74 As of 31 March 2021, there are in total 336 airports in the programme worldwide. They represent 74 countries and 45.9% of global air passenger traffic. 112 reached a Level 1, 96 a Level 2, 63 a Level 3 and 60 a Level 3+ accreditation. Furthermore, five airports have already achieved accreditation at the newly introduced levels: 1 a Level 4 and 4 airports a Level 4+ accreditation.

4.75 One of its essential requirements is the verification by external and independent auditors of the data provided by airports. The Administrator of the programme has been collecting CO_2 data from participating airports since the programme launch. This has allowed the absolute CO_2 reduction from the participation in the programme to be quantified.

4.76 Aggregated data are included in the Airport Carbon Accreditation Annual Reports thus ensuring transparent and accurate carbon reporting. At Level 2 of the programme and above, airport operators are required to demonstrate CO_2 reductions associated with the activities they control.

4.77 The Annual Report, which is published in the fall of each year, typically covers the previous reporting year (i.e., mid-May to mid-May) and presents the programme's evolution and achievements. However, because of the extraordinary conditions faced in 2020 due to COVID-19 pandemic, special provisions are applied to all accredited airports, including the merge of programme years 11 and 12, which implies the extension of accreditation validity by one year. Thus, the current Airport Carbon Accreditation certification period covers the timespan May 2019 to May 2021. For this reason, the last published Report is considered as an Interim Report which addresses only a part of the on-going reporting period (i.e., from 16th May 2019 to 11th December 2020), and as such does not include the usual carbon Key Performance Indicators, but only valuable information regarding key achievements and developments, the most significant global and regional trends, and case studies highlighting the airports' commitment to continued climate action in spite of the current crisis. Therefore, the tables below show carbon performance metrics until the 2018/2019 regular reporting cycle.

4.78 For historical reasons European airports remain at the forefront of airport actions to voluntarily mitigate and reduce their impact on climate change. The strong growth momentum is still being maintained as there are 167 airports in the programme. These airports account for 69.7% of European air passenger traffic.

Table 11: Emissions reduction highlights for the European region

	2009-2010	2010-2011	2011-2012	2012-2013	2013-2014	2014-2015	2015-2016	2016-2017	2017-2018	2018-2019
Total aggregate scope 1 & 2 reduction (ktCO_2)	51.7	54.6	48.7	140	130	169	156	155	169	158
Total aggregate scope 3 reduction (ktCO_2)	360	675	366	30.2	224	551	142	899	1160	1763

Table 12: Emissions offset for the European region

	2015-2016	2016-2017	2017-2018	2018-2019
Aggregate emissions offset, Level 3+ (tCO_2)	222339	252218	321170	375146

4.79 The table above presents the aggregate emissions offset by airports accredited at Level 3+ of the programme in Europe. The programme requires airports at Levels 3+ and 4+ to offset their residual Scope 1 & 2 emissions as well as Scope 3 emissions from staff business travel.

Table 13: Airport Carbon Accreditation key performance indicators 2018/2019

Indicator	**Unit**	**Time Period (2018/2019)**	**Absolute change compared to the 3-year rolling average**	**Change (%)**
Aggregate scope 1 & 2 emissions from airports at Levels 1-3+	tCO_2	6,520,255	-322,297	-4.9%
Scope 1 & 2 emissions per passenger from airports at Levels 1-3+	kgs of CO_2	1.81	-0.09	-4.3%
Scope 1 & 2 emissions per traffic unit from airports at Levels 1-3+	kgs of CO_2	1.55	-0.08	-4.3%
Indicator	**Unit**	**Time Period (2018/2019)**	**Absolute change (vs. previous year)**	**Change (%)**
Offsetting of aggregate scope 1 & 2 & staff business travel emissions from airports at Level 3+	tCO_{2e}	710,673	38.673	5.8%
Indicator	**Unit**	**Time Period (2018/2019)**	**Absolute change (vs. previous year)**	**Change (%)**
Scope 3 emissions from airports at Levels 3 and 3+	tCO_2	60,253,685	6,895,954	12.9%

4.80 The programme's main immediate environmental co-benefit is the improvement of local air quality.

4.81 Costs for the design, development and implementation of Airport Carbon Accreditation have been borne by ACI EUROPE. Airport Carbon Accreditation is a non-for-profit initiative, with participation fees set at a level aimed at allowing for the recovery of the aforementioned costs.

4.82 The scope of Airport Carbon Accreditation, i.e. emissions that an airport operator can control, guide and influence, implies that as of Level 3, aircraft emissions are also covered. Thus, airlines can benefit from the gains made by more efficient airport operations to see a decrease in their emissions. This is consistent with the ambition of the European Green Deal, the inclusion of aviation in the EU ETS and the implementation of CORSIA and therefore can support the efforts of airlines to reduce these emissions.

ASSESSMENT

4.83 The inclusion of this collective European measure is descriptive for information purposes, and no quantitative assessment of its benefits in terms of reduction in aviation emissions is provided in the common section of this action plan.

Destination 2050

4.84 The Destination 2050[50] is an initiative and roadmap developed by aviation industry stakeholders (A4E, ACI EUROPE, ASD, CANSO and ERA) showing an ambitious decarbonisation pathway for European aviation.

4.85 These European industry organizations commit to work together with all stakeholders and policymakers to achieve the following climate objectives:

- Reaching net zero CO_2 emissions by 2050 from all flights within and departing from the European Economic Area, Switzerland and the UK. This means that by 2050, emissions from these flights will be reduced as much as possible, with any residual emissions being removed from the atmosphere through negative emissions, achieved through natural carbon sinks (e.g., forests) or dedicated technologies (carbon capture and storage). For intra-EU flights, net zero in 2050 might be achieved with close to no market-based measures.
- Reducing net CO_2 emissions from all flights within and departing from the European Economic Area, Switzerland and the UK by 45% by 2030 compared to the baseline[51]. In 2030, net CO_2 emissions from intra-EU flights would be reduced by 55% compared to 1990 levels.
- Assessing the feasibility of making 2019 the peak year for absolute CO_2 emissions from flights within and departing from the European Economic Area, Switzerland and UK.

[50] www.destination2050.eu
[51] A hypothetical 'no-action' scenario whereby CO_2 emissions are estimated based on the assumption that aircraft deployed until 2050 have the same fuel efficiency as in 2018.

4.86 With the Destination 2050 roadmap and through these commitments, the European aviation sector contributes to the Paris Agreement, recognising the urgency of pursuing the goal of limiting global warming to 1.5°C.

4.87 By doing so, the European aviation sector is also effectively contributing to the collective European Green Deal and EU's climate neutrality objectives.

4.88 This roadmap is complementary to the WayPoint 2050 Air Transport Action Group (ATAG) global pathway for the decarbonization of aviation.

ASSESSMENT

4.89 The inclusion of this collective European measure is descriptive for information purposes, and no quantitative assessment of its benefits in terms of reduction in aviation emissions is provided in the common section of this action plan.

5. UK aviation emissions

Historic emissions and the UK baseline

5.1 To quantify the impact of UK mitigation measures discussed in Chapter 6, a baseline scenario covering UK emissions from international aviation is presented below. The scenario is not intended to replace data submitted to ICAO through the ECAC common section in Chapter 3, rather it is included to allow for the quantification of UK specific abatement measures.

5.2 The data set out in Table 1 and Figure 1 reflect a "do nothing" or "no mitigation" scenario. Demand growth has been estimated using the 2017 Department for Transport forecasts with total passenger numbers (for domestic and international aviation) increasing from 277 million in 2020 to 515 million in 2050.

5.3 The scenario does not consider the impact of the COVID-19 pandemic due to a lack of available data. The scenario assumes no carbon price, no uptake of sustainable aviation fuels and no introduction of zero emission aircraft. Airport capacity constraints are in line with the UK's Making Best Use policy[52] and include estimates for a third runway at Heathrow airport. An annual efficiency improvement of 0.5% pa from 2017-2050 is assumed.

Table 1: UK historic emissions from international aviation 2016-2019 and forecast emissions from 2020-2050

Year	UK International aviation carbon emissions (Mt CO_2)	Fuel consumption (Mt kerosene)
2016 *(historic)*	33.38	10.60
2017 *(historic)*	35.92	11.40
2018 *(historic)*	36.29	11.52
2019 (*historic*)	36.66	11.64
2020 *(forecast)*	34.96	11.10
2025 *(forecast)*	35.91	11.40
2030 *(forecast)*	40.67	12.91
2035 *(forecast)*	42.61	13.53
2040 *(forecast)*	45.02	14.29
2045 *(forecast)*	50.04	15.89
2050 *(forecast)*	54.91	17.43

[52] Making Best Use policy

Data sources and methodology

5.4 Data from 2016 to 2019 represents historical emissions taken from "Final UK greenhouse gas emissions national statistics: 1990 to 2019"[53]. Forecast emissions data from 2020 to 2050 are taken from the Department for Transport aviation model forecasts[54] and represent UK departing freight and passenger flights only.

5.5 For all years, fuel consumption is calculated by dividing expected emissions by 3.15, the carbon intensity of kerosene.

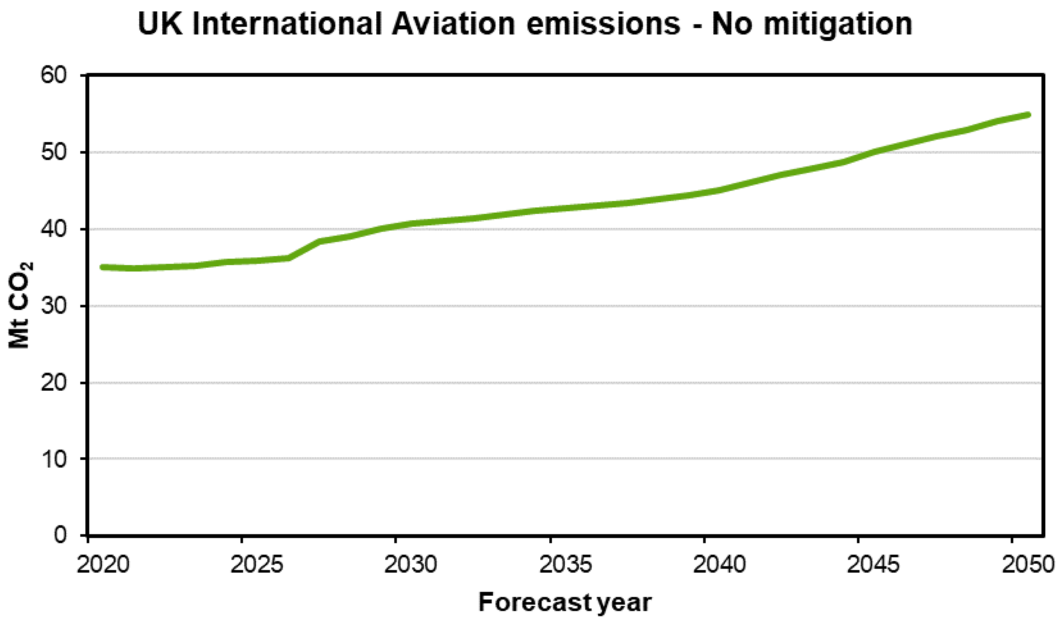


Figure 1: UK International Aviation emissions forecasts from departing UK flights 2020- 2050.

[53] Final UK greenhouse gas emissions national statistics:1990 to 2019
[54] Department for Transport aviation model

6. UK actions to mitigate the environmental impacts of aviation

UK policy on aviation emissions

6.1 The UK was the first major economy to pass laws to end its contribution to climate change by 2050. It is critical that the aviation sector plays its part in delivering the UK's net zero commitment and the Government is already supporting a variety of technology, fuel and market-based measures to address aviation emissions.

6.2 In addition, the UK government has established the Jet Zero Council, a partnership between industry and government to bring together senior leaders in aviation, aerospace and academia to drive the delivery of new technologies, with the aim of delivering zero-emission transatlantic flight within a generation. To achieve this, it will consider how to develop and industrialise clean aviation and aerospace technologies, establish UK production facilities for sustainable aviation fuels (SAF) and develop a coordinated approach to the policy and regulatory framework needed to deliver net zero aviation by 2050. To accelerate progress, two Delivery Groups have been established focussing on the Council's priority areas: SAF and Zero-Emission Flight.

6.3 In line with recommendations from the Government's independent climate advisors, the Climate Change Committee, the UK has set its sixth carbon budget (2033-37) to include international aviation and shipping (IAS) emissions. IAS emissions are an important part of the UK's overall decarbonisation efforts and this change allows for these emissions to be accounted for consistently with other emissions included within the sixth carbon budget. The UK remains fully committed to global action to tackle international aviation emissions through international processes at ICAO.

6.4 The UK is also negotiating for ICAO to agree a long-term emissions reduction goal for international aviation by its 41st Assembly in 2022. The UK believes the development of a long-term goal is paramount to enabling effective decarbonisation of the international aviation industry.

6.5 The UK is committed to achieving net zero emissions across the whole economy by 2050 and as such, the Government recently launched its Jet Zero Consultation[55] which will inform the final Jet Zero Strategy to be published later in 2021. The Strategy will set out the government's vision for reaching net zero aviation by 2050, and the principles and measures that will be employed to get there.

UK Emissions Trading Scheme

6.6 On 1 January 2021 the UK Government established a UK Emissions Trading Scheme (UK ETS) to replace the UK's participation in the EU Emissions Trading System (EU ETS). The UK ETS covers emissions from the UK's power sector,

[55] UK government consultation launched 14th July 2021: Jet zero: our strategy for net zero aviation

heavy industry and aviation, constituting around a third of total UK emissions. The UK ETS currently covers all domestic flights, flights from the UK to the European Economic Area and flights between the UK and Gibraltar. In 2019, these flights made up 44% of all commercial flights to and from UK airports.[56]

6.7 The UK ETS works on the 'cap and trade' principle. A cap is set on the total amount of greenhouse gases that can be emitted by the sectors covered by the scheme. The cap is divided into allowances, and participants receive or purchase emission allowances which they can trade with one another as needed. This cap is reduced over time, so that total emissions fall. The flexibility that trading brings ensures that emissions are cut where it costs least to do so. Participants are required to monitor their emissions during a calendar year, surrendering one emissions allowance for every tonne of carbon dioxide equivalent (CO_2e) they have emitted at the end of each reporting year.

6.8 The UK ETS will be the world's first net zero carbon cap and trade market, and a crucial step towards achieving the UK's target for net zero carbon emissions by 2050. The UK ETS cap is 5% lower than the UK's notional share of the EU ETS cap, and the UK Government will be consulting shortly on how to align the cap with an appropriate net zero trajectory.

6.9 The UK will also develop and improve the system for aviation, for example by reviewing the sector's free allocation, exploring expansion of the pollutants in scope and determining how the UK ETS will interact with the new global offsetting scheme for aviation, CORSIA.

Carbon Offsetting and Reduction for International Aviation (CORSIA)

6.10 The UK has long supported strong, concerted international action to tackle the contribution of international aviation to climate change. The UK has been actively involved in the development of CORSIA by ICAO and is committed to implementing the scheme. The UK is one of 88 states that have signed up to the voluntary phase of CORSIA, which commenced in 2021.

6.11 In January 2021, the UK consulted on the monitoring, reporting and verification (MRV) requirements relating to CORSIA.[57] An Air Navigation Order (ANO) putting these MRV provisions into UK law came into force at the end of May. A second consultation later this year will cover the CORSIA offsetting requirements and consider how the scheme will be implemented alongside the UK ETS, given that flights departing the UK to aerodromes in the European Economic Area (EEA) are in scope of both CORSIA and the UK ETS. An amendment to the ANO will cover the second part of CORSIA implementation, and we are aiming for this to come into force during spring 2022.

6.12 Consequential amendments to UK ETS legislation may be required as a result of the chosen policy option for interaction between CORSIA and the UK ETS. Any such amendments to both the CORSIA ANO and the UK ETS will be in force no later than the start of UK ETS Phase 1(b) in 2024.

[56] DfT (n.d). Internal DfT analysis of CAA airports data.
[57] https://www.gov.uk/government/consultations/implementing-the-carbon-offsetting-and-reduction-scheme-for-international-aviation/implementing-the-carbon-offsetting-and-reduction-scheme-for-international-aviation-corsia

Sustainable Aviation Fuel (SAF)

6.13 Alongside other measures, sustainable aviation fuels (SAF) are an important measure available to decarbonise aviation: given the lifecycle emissions reduction SAF can achieve (on average, over 70%) compared to conventional fossil fuel and the limited changes it requires to existing aircraft and infrastructure (SAF can be easily blended into existing fuel mix). The UK is keen to capitalise on this technology and the associated environmental and industrial opportunities it can bring about.

6.14 The Renewable Transport Fuel Obligation (RTFO), a certificate trading scheme, places an obligation on fuel suppliers to ensure that a certain proportion of the fuel they supply is of renewable origin. Fuel suppliers who supply at least 450,000 litres of fuel a year are affected. This includes suppliers of biofuels as well as suppliers of fossil fuel. The current obligation level is 9.75% of total fuel supplied for road transport and non-road mobile machinery, this will increase incrementally to 12.4% of total fuel by 2032.

6.15 The RTFO focuses on promoting waste-derived rather than crop-derived biofuels to deliver the highest possible greenhouse gas (GHG) savings. For this reason, the use of crops for biofuels, and in particular oil seeds such as palm oil, soya and oilseed rape, is minimal in the UK.

6.16 All claims for support under the RTFO are subject to independent verification and we take a risk-based approach to determining if further supporting evidence is required. In addition, 99% of the biofuel supplied is also covered by sustainability assurance schemes which provide additional checks at each step of the chain of custody.

6.17 As a result, on top of the existing support through the RTFO and the Future Fuels for Flight and Freight Competition (F4C), the UK Prime Minister announced on 18 November 2020 a package of support for SAF as part of his ‘Ten-Point Plan to Build Back Greener’. This includes:

- A consultation on the introduction of a SAF mandate, that would create an obligation to bring an increasing amount of SAF to the market year by year, driving up demand for SAF while providing a clear, long-term signal to industry;
- A £15m Green Fuels, Green Skies competition, which launched in March 2021, providing capital funding to support the feasibility stage and early aspects of engineering/design work for UK based commercial scale SAF plants;
- A £3m fund to set up a SAF clearing house in the UK, which will be a national fuel testing hub, capable of delivering early stage aviation fuel testing, funding and expert advice for new fuels looking to enter testing at all certification stages/pathways.

6.18 Supported by industry and the Jet Zero Council’s SAF Delivery Group, work is in progress to explore the implications on feedstock and technology underpinned by SAF use and production in the UK and to understand whether additional measures to support local SAF production are needed. The UK is keen to ensure that domestic SAF policies, in particular a SAF mandate, interact smoothly with international policies and agreements so that SAF can offer a pragmatic and effective way to decrease carbon emissions and ultimately avoid carbon leakage.

Airspace modernisation

6.19 Airspace modernisation can deliver quicker, quieter and cleaner journeys. It will utilise new technologies to create more direct routes, faster climbs, and reduced need for holding stacks. This will mean the aviation industry can grow safely with opportunities to reduce noise and carbon emissions and to provide better access to airspace for all users.

6.20 The UK Government is funding £5.5m towards airspace modernisation, supporting airports to progress their individual airspace programmes. A wide range of organisations from across the aviation industry are working together on the investment programme to upgrade UK airspace.

6.21 The programme of airspace modernisation will deliver a once-in-a generation upgrade to critical UK national infrastructure, and is critical in supporting the future of aviation delivering net zero.

Research, development and new technology

6.22 New and emerging aircraft technology will play an important role in reducing the impact of aviation on the environment. This includes the development of more efficient large passenger aircraft and emerging, potentially transformational, technology on smaller platforms that could unlock zero-carbon emission flight.

6.23 The UK Government is investing £1.95 billion towards mid-stage aerospace research and development from 2013 to 2026, which with match-funding by industry gives a total budget of £3.9 billion. Funding is guided by the UK's Aerospace Technology Strategy, developed by the Aerospace Technology Institute (ATI), with the aim of maximising the UK's economic benefit from manufacturing greener commercial aircraft.

6.24 In July 2020 the UK Government announced the FlyZero project, funded with a £15 million grant from Government, to investigate the design challenges and market opportunity of potential zero-carbon emission aircraft concepts. The year-long study will bring together experts from across the aerospace industry, with outcomes expected in early 2022.

6.25 Through UK Research and Innovation (UKRI), Government is investing up to £125 million on the Future Flight Challenge. This challenge aims to develop greener ways to fly, such as all-electric aircraft and deliveries by drone, by advancing electric and autonomous flight technologies. The investment is matched by £175 million from industry.

6.26 As part of the Government's 'Ten Point Plan for a Green Industrial Revolution'[58], £3 million funding was announced for research and development into the infrastructure that will be needed at airports to support the introduction of new electric and hydrogen aircraft.

6.27 The UK is also supporting the development of a Transport hydrogen hub. Located in the Tees Valley, it will support research, testing and aircraft trials as part of its cross-modal work to better the understanding of hydrogen's role in reaching net zero by 2050. Later this year the UK Government plans to launch its Hydrogen Strategy. This will set out an action plan to decarbonise and expand hydrogen production and is

[58] The UK Government's Ten Point Plan for a Green Industrial Revolution

supported by £240m of funding announced in the ‘Ten Point Plan for a Green Industrial Revolution’.

Industry

6.28 UK industry continues to investigate and develop innovative ways of addressing aviation’s climate change emissions through the use of new technologies, sustainable aviation fuels and market-based measures.

6.29 Sustainable Aviation (SA) was launched in 2005 as a coalition of UK airlines, airports, aerospace manufacturers, air traffic service providers, and key business partners, as has led a number of activities to reduce UK aviation CO_2 emissions. In February 2020, SA launched its Decarbonisation Roadmap: A Path to Net Zero[59]. The report highlights the need for a partnership approach with government, as well as an international approach to avoid unintended consequences such as undermining the UK’s international connectivity or creating CO_2 emissions elsewhere outside of the UK. The report also sets out how the UK aviation industry can achieve net zero carbon emissions by 2050, including through: impact on demand due to carbon pricing; better air traffic management and operating procedures; the introduction of known and new, more efficient aircraft; sustainable aviation fuels, and effective market-based measures.

Non-government organisations

6.30 The UK’s non-government organisation (NGO) sector is also active in engaging on aviation and climate change issues. DfT works closely with organisations like the Aviation Environment Federation on CO_2 emissions from aviation, as well as a range of other topics including noise, air quality and natural resources.

NATS action on climate change

6.31 While aviation’s climate change impacts are well known, the impact that NATS can have on these externalities is limited, but still forms a crucial part of the wider industry effort to decarbonise. NATS’ goal is to work with industry partners to play its part in contributing to the net zero requirements of aviation in the UK. This builds on past environmental targets and programmes that have been in place since 2008. In addition to the benefits realised through airspace modernisation, NATS continues to influence aviation CO_2 emissions in numerous ways, including the development of oceanic airspace, the day-to-day management of airspace, and tactical delivery of efficient flight profiles by our air traffic controllers.

NATS mitigation measures

6.32 Improvements to the efficiency of UK airspace under NATS’ control have been driven by performance targets set by the UK aviation regulator (CAA) and NATS’ original commitment to reduce CO_2 emissions by an average 10% per flight relative to a 2006 baseline, by 2020.

6.33 Recent examples of improvements delivered by NATS include:

[59] Sustainable Aviation: A Path to Net Zero

- Improvements to the structure of airspace, such as minor changes to procedures[60] and airspace redesign[61] to deliver more direct routes and vertically efficient flight profiles. A recent tranche of changes was delivered in 2021 which removed an initial set of network restrictions to deliver more efficient flight profiles.
- Improvements to the tactical delivery of flight profiles, e.g. through best practice, training and awareness[62] to increase continuous climbs and descents[63], supporting optimised speed profiles and arrivals holding reductions[64], and through coordination between airspace sectors offering direct routeing or re-routing aircraft through a military training/danger area when the sector is no longer being used actively by the military[65].
- Implementation of controller support tools and concepts of operation, e.g. to optimise the horizontal and vertical trajectories of aircraft[66], avoid holding at airports[67] or to space the arriving aircraft by time rather than by distance[68].
- Ensuring the UK has the right communication, navigation and surveillance systems in the right place to help optimise the airspace network and provision of air traffic control.

6.34 Airspace modernisation is expected to deliver significant CO_2 savings to aircraft by employing the above solutions. Initiatives at an advanced stage of planning for implementation by NATS this decade include:

- Improvements arising from the systemisation of lower airspace infrastructure[69]Free Route Airspace (FRA)[70] which underpins the modernisation of the upper airspace in 2020's, in line with the UK Airspace Modernisation Strategy.
- Improvements to Oceanic airspace (OTS)[71].
- The expanded use of Intelligent Approach[72], including Time Based Separation (TBS).

CAA action on climate change

6.35 The CAA's strategic aims in relation to the environment are:

- To encourage and incentivise the aviation sector to manage and reduce its negative impacts, including emissions and noise.
- Co-lead airspace modernisation to deliver cleaner, greener, quicker journeys and expand airspace availability.

[60] NATS (2016) A quiet evolution in airspace management
[61] NATS (2016) LAMP airspace change to go live
[62] NATS (2021) New environment training reaches parts other sustainability initiatives haven't
[63] Sustainable Aviation (2014) Continuous descents
[64] Heathrow Airport (2018) Tactically Enhanced Arrivals Mode
[65] NATS (2019) Giving fighter jets the space to fly
[66] NATS (2013) How technology is transforming air traffic management
[67] NATS Why new streamlined Heathrow arrivals start in Europe
[68] NATS Time based separation
[69] NATS Redesigning the skies
[70] Borealis (2016) Free route airspace animation
[71] Is it time to disband the Organised Track Structure?
[72] Intelligent Approach - The benefits

- Enable the safe and effective regulation of innovative services and products to improve environmental sustainability and performance.
- The mechanisms to deliver these aims vary across the CAA's discrete activities but are broadly summarised as maximising the potential of enabling carbon reduction where the CAA has relevant regulatory roles, and providing advice and insight to government across its portfolio.

6.36 These roles include regulating the introduction of technologies and innovations to achieve low or emission-free flights, overseeing the airspace modernisation strategy which aims to achieve quieter, cleaner and quicker journeys as well as assessing the merits of individual airspace changes, including their environmental impacts. The CAA also has powers relating to the provision of information to help consumers compare services and air travel's environmental effects, which were granted by the Civil Aviation Act 2012.

6.37 In recent years the CAA has witnessed changes in both the broader public and consumer attitudes with regard to the environment and has initiated a project to explore the possibility and feasibility of sharing information on the impacts of aviation on the environment with consumers, to enable better decision-making and inform the government's transport decarbonisation programme, towards the net zero target. Building on significant consumer research in early 2021 and stakeholder engagement, the CAA intends to consult later in 2021 on a range of options to provide consumers with better environmental impacts information to inform their purchasing decisions.

6.38 Lastly, the CAA has a role to provide advice to government about the implementation of market-based measures, (specifically in relation to CORSIA), and any other relevant environmental insight or intelligence government seeks.

6.39 As the CAA considers its environmental roles going forward, it remains closely engaged with the UK government to ensure that its activities are aligned with DfT policy goals, and are able to work effectively within the international environmental context.

Non-CO_2 emissions

6.40 Tackling the climate impact of aviation is not just about reducing CO_2. Whilst the long-life span of CO_2 in the atmosphere makes tackling it of critical importance, there are other, non-CO_2 emissions and effects that also impact on the climate and local air quality: in particular contrails and NO_x emissions. Contrails and NOx emissions are understood to create a net warming effect in addition to any CO_2 emissions, though the exact scale of the impact has a large relative uncertainty.

6.41 Local air quality impacts from aviation occur in areas around airports, accounting for a small proportion of emissions. Aircraft NO_x emissions have long been regulated for air quality purposes, which is understood to have climate benefits. The UK played a leading role in the adoption by ICAO in 2019 of the first scientifically-based certification standards for aircraft non-volatile particulate emissions, which will again have local air quality and climate benefits.

6.42 Many of the measures to improve aviation system efficiencies, rollout SAF and accelerate zero emission flight are expected to have a positive impact on reducing non-CO_2 emissions and effects. The UK government is working to improve understanding of the impact of non-CO_2 emissions and ensure that the latest scientific understanding of aviation non-CO_2 effects is used to inform policy.

7. UK mitigation measures – expected results

7.1 The data presented in Table 2 and Figure 2 reflect the expected CO_2 emissions savings from the implementation of carbon pricing, uptake of sustainable aviation fuels, and aircraft and operational efficiency gains. Emissions savings from aircraft and operational efficiencies are provided for completeness only and not for the purposes of submitted data to ICAO. Technological improvements are already accounted for in the data provided through the ECAC common section.

7.2 The scenarios set out below do not take into account the impact of COVID-19 and airport capacity constraints are the same as for the baseline scenario. Assumptions on carbon pricing are taken from the UK Department for Business, Energy and Industrial Strategy (BEIS) central traded carbon price series for appraisal[73], applied to all UK-departing flights, which limits the increase in total passenger numbers from 277 million in 2020 to 466 million in 2050.

Table 2: Expected impact of mitigation measures to reduce UK international aviation CO_2 emissions.

Year	UK international aviation carbon emissions - Baseline Scenario (Mt CO_2)	Emissions savings from carbon price (Mt CO_2)	Emissions savings from SAF (Mt CO_2)	Emissions savings from aircraft and operational efficiency gains (Mt CO_2)[74]	Total emissions savings (Mt CO_2)	Remaining emissions after implementation of measures (Mt CO_2)
2016 (historic)	33.38					
2017 (historic)	35.92					
2018 (historic)	36.29					
2019 (historic)	36.66					
2020 (*forecast*)	34.96	0.01			0.01	34.94
2025 (*forecast*)	35.91	1.00	0.15		1.15	34.77
2030 (*forecast*)	40.67	1.60	0.37	0.24	2.21	38.46
2035 (*forecast*)	42.61	1.96	0.63	1.78	4.37	38.24
2040 (*forecast*)	45.02	2.70	0.89	5.96	9.54	35.48
2045 (*forecast*)	50.04	3.89	1.26	9.95	15.10	34.95
2050 (*forecast*)	54.91	4.95	1.72	14.01	20.68	34.24

[73] BEIS 'Valuation of Energy Use and Greenhouse Gas'
[74] Savings from aircraft and operational efficiency gains are included for completeness only and are not intended for ICAO accounting purposes.

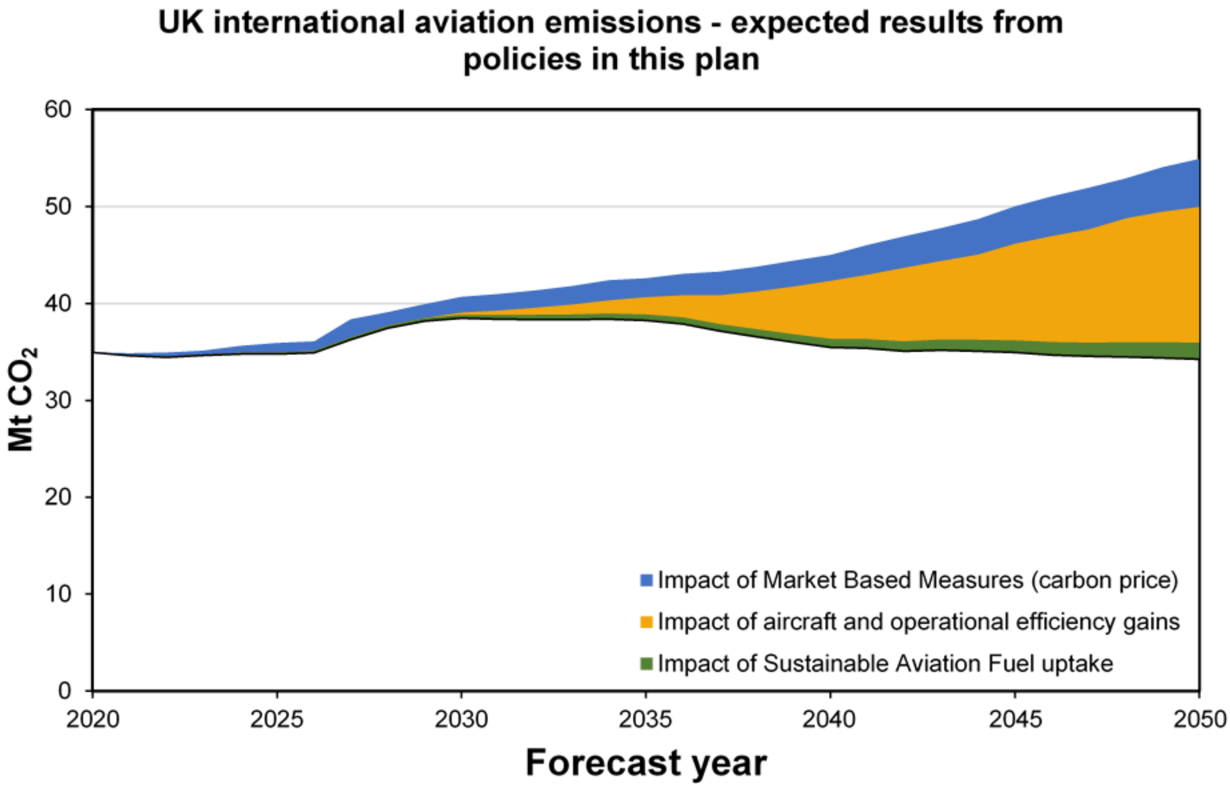


Figure 2: Expected results from UK mitigation measures on UK international aviation CO_2 emissions. The above estimates are based on assumptions of the continuation of existing UK policy measures. The analysis does not take into account new or future measures that may be implemented.

7.3 The forecast above assumes a 5% uptake of SAF by 2050, a 1.5% annual increase in fuel efficiency and no uptake of zero emission aircraft by 2050. It does not consider the impact of any new measures that may be adopted by the UK in the future (the Government has recently published its Jet Zero Consultation[75], setting out its vision for the aviation sector to reach net zero). The forecast below focuses solely on in-sector CO_2 reductions and does assess the impact of out-of-sector reductions such as carbon offsetting.

Data sources and methodology

7.4 Data from 2016 to 2019 represents actual outturn emissions taken from “Final UK greenhouse gas emissions national statistics: 1990 to 2019”[76]. Forecast emissions data from 2020 to 2050 is taken from the Department for Transport aviation model forecasts[77] and represents UK departing freight and passenger flights only.

7.5 For all years, fuel consumption is calculated by dividing expected emissions by 3.15, the carbon intensity of kerosene, after taking into account the proportion of SAF in the fuel mix.

[75] Jet zero: our strategy for net zero aviation
[76] Final UK greenhouse gas emissions national statistics:1990 to 2019
[77] Department for Transport aviation model

8. Conclusion

8.1 This Action Plan provides an overview of the actions undertaken at a national level in the UK and those taken collectively throughout Europe to address CO_2 emissions from aviation and to contribute to the development of a resource-efficient, competitive and sustainable multimodal transport system.

8.2 The UK national actions (Chapter 6) of this Action Plan were completed in June 2021 and shall be considered as subject to update after that date.

9. Appendix A

Detailed results for ECAC scenarios from Chapter 3

BASELINE SCENARIO

a) Baseline forecast for international traffic departing from ECAC airports

Year	Passenger Traffic (IFR movements) (million)	Revenue Passenger Kilometres[78] RPK (billion)	All-Cargo Traffic (IFR movements) (million)	Freight Tonne Kilometres transported[79] FTKT (billion)	Total Revenue Tonne Kilometres[80] RTK (billion)
2010	4.56	1,114	0.198	45.4	156.8
2019	5.95	1,856	0.203	49.0	234.6
2030	5.98	1,993	0.348	63.8	263.1
2040	7.22	2,446	0.450	79.4	324.0
2050	8.07	2,745	0.572	101.6	376.1

Note that the traffic scenario shown in the table is assumed for both the baseline and implemented measures scenarios.

b) Fuel burn and CO_2 emissions forecast for the baseline scenario

Year	Fuel Consumption (10^9 kg)	CO_2 emissions (10^9 kg)	Fuel efficiency (kg/RPK)	Fuel efficiency (kg/RTK)
2010	36.95	116.78	0.0332	0.332
2019	52.01	164.35	0.0280	0.280
2030	50.72	160.29	0.0252	0.252
2040	62.38	197.13	0.0252	0.252
2050	69.42	219.35	0.0250	0.250
For reasons of data availability, results shown in this table do not include cargo/freight traffic.				

[78] Calculated on the basis of Great Circle Distance (GCD) between airports, for 97% of the passenger traffic for forecast years.

[79] Includes passenger and freight transport (on all-cargo and passenger flights).

[80] A value of 100 kg has been used as the average mass of a passenger incl. baggage (ref: ICAO).

2. IMPLEMENTED MEASURES SCENARIO

2A) EFFECTS OF AIRCRAFT TECHNOLOGY IMPROVEMENTS AFTER 2019

a) Fuel consumption and CO_2 emissions of international passenger traffic departing from ECAC airports, with aircraft technology improvements after 2019 included:

Year	Fuel Consumption (10^9 kg)	CO_2 emissions (10^9 kg)	Well-to-wake CO_2e emissions (10^9 kg)	Fuel efficiency (kg/RPK)	Fuel efficiency (kg/RTK)
2010	36.95	116.78	143.38	0.0332	0.332
2019	52.01	164.35	201.80	0.0280	0.280
2030	49.37	156.00	191.54	0.0232	0.232
2040	56.74	179.28	220.13	0.0217	0.217
2050	59.09	186.72	229.26	0.0202	0.202
For reasons of data availability, results shown in this table do not include cargo/freight traffic.					

b) Average annual fuel efficiency improvement for the Implemented Measures Scenario (new aircraft technology only)

Period	Average annual fuel efficiency improvement (%)
2010-2019	-1.86%
2019-2030	-1.22%
2030-2040	-0.65%
2040-2050	-0.74%

2B) EFFECTS OF AIRCRAFT TECHNOLOGY AND ATM IMPROVEMENTS AFTER 2019

a) Fuel consumption and CO_2 emissions of international passenger traffic departing from ECAC airports, with aircraft technology and ATM improvements after 2019:

Year	Fuel Consumption (10^9 kg)	CO_2 emissions (10^9 kg)	Well-to-wake CO_2e emissions (10^9 kg)	Fuel efficiency (kg/RPK)	Fuel efficiency (kg/RTK)
2010	36.95	116.78	143.38	0.0332	0.332
2019	52.01	164.35	201.80	0.0280	0.280
2030	46.16	145.86	179.09	0.0217	0.217
2040	51.06	161.35	198.12	0.0196	0.196
2050	53.18	168.05	206.33	0.0182	0.182
For reasons of data availability, results shown in this table do not include cargo/freight traffic.					

b) Average annual fuel efficiency improvement for the Implemented Measures Scenario (new aircraft technology and ATM improvements)

Period	Average annual fuel efficiency improvement (%)
2010-2019	-1.86%
2019-2030	-1.82%
2030-2040	-1.03%
2040-2050	-0.74%

c) Equivalent (well-to-wake) CO_2e emissions forecasts for the scenarios described in this common section

Year	Well-to-wake CO_2e emissions (10^9 kg)			% improvement by Implemented Measures (full scope)
	Baseline Scenario	Implemented Measures Scenario		
		Aircraft techn. improvements only	Aircraft techn. and ATM improvements	
2010	143.38			NA
2019	201.80			NA
2030	196.8	191.5	179.1	-9%
2040	242.0	220.1	198.1	-18%
2050	269.3	229.3	206.3	-23%
For reasons of data availability, results shown in this table do not include cargo/freight traffic. Note that fuel consumption is assumed to be unaffected by the use of sustainable aviation fuels.				

10. Appendix B

Note on the methods to account for the CO_2 emissions attributed to international flights

Background

The present note addresses recommendations on the methodologies to account the CO_2 emissions, for the guidance on the development of the common European approach for ECAC States to follow, in view of the submission to ICAO of their updated State Action Plans for CO_2 Emissions Reduction (APER).

The ECAC APER guidance shall be established on the basis of the ICAO 9988 Guidance on the Development of States' Action Plans on CO_2 Emissions Reduction Activities document (3rd edition). One of its objectives is to define a common approach for accounting CO_2 emissions of international flights: two different methods are proposed for CO_2 accounting, namely ICAO and IPCC. Because of their intrinsic definitions, it is expected that these two different approaches induce both accounting differences, and practical issues, and furthermore, two ways to target the CO_2 Emissions Reduction Activities, and to define the action plans, de facto.

As the objective of the definition of the common section of the ECAC APER guidance consists into determining a common approach for all the foreseen activities, including CO_2 accounting and monitoring, the ECAC APER Task Group required to assess the details of each methods and to propose recommendations in this present note.

2. Accounting methods

The ICAO Doc 9988 document 3rd edition defines the two CO_2 accounting methods (§3.2):

a) ICAO: each State reports the CO_2 emissions from the international flights operated by aircraft registered in the State (State of Registry).

b) IPCC: each State reports the CO_2 emissions from the international flights departing from all aerodromes located in the State or its territories (State of Origin).

The international flights concern aircraft movements from a country to another country. Each method determines the country assignment of the movement.

Method	**ICAO**	**IPCC**
Definition	The ICAO methodology is based on the State of nationality of the airline, and defines an "international" flight as one undertaken to or from an airport located in a State other than the airline's home State, i.e. each State reports only on the international activity of its own commercial air-carriers.	The IPCC methodology defines international aviation as flights departing from one country and arriving in another, i.e. each State report to IPCCs in respect of all flights departing from their territory, irrespective of the nationality of the operator.
Use in projects	CORSIA/ETS (partially)	IPCC EAER UNFCCC

2.1 Comparisons: flown distance and number of operations

The comparison of the number of operations and flown distance of 2019, aggregated at ECAC or State levels provide a good indication of the possible differences for CO_2 accounting.

At the ECAC area level, the relative difference between the ICAO and IPCC methods, is -0.66% for operations number and + 0.26% on flown distance (Source EUROCONTROL/CRCO). This is explained by the fact that movements of the operators registered outside the ECAC area member states are not counted in.

The table hereafter lists the countries for which the relative differences of counting the number of operations or flown distance is more than 50% or less than -50% (Source EUROCONTROL/CRCO).

DEPARTURE COUNTRY	(ICAO – IPCC) % difference number of operations	(ICAO – IPCC) % difference number of flown distance
ALBANIA	-71.04%	-75.34%
ARMENIA	-80.76%	-84.64%
AUSTRIA	114.51%	104.81%
BOSNIA AND HERZEGOVINA	-83.45%	-80.73%
CROATIA	-52.08%	-65.54%
CYPRUS	-84.06%	-92.75%
DENMARK	-68.07%	-53.81%
ESTONIA	-67.93%	-53.48%
FAROE ISLANDS	*-100.00%*	*-100.00%*
GEORGIA	-68.62%	-66.45%
GREECE	-58.26%	-65.83%
HUNGARY	213.95%	245.36%
IRELAND	509.31%	478.00%
ITALY	-71.45%	-63.90%
LIECHTENSTEIN	2100.00%	8572.91%
LITHUANIA	-78.83%	-65.95%
LUXEMBOURG	55.29%	54.05%
NORTH MACEDONIA	-98.69%	-98.90%
MALTA	97.00%	125.78%
MONACO	100.17%	708.97%
SLOVAKIA	-73.46%	-72.30%

The previous table highlights the possible relative differences for a country-by-country approach:

- High differences for low-cost origin countries (Ireland, Austria, Hungary) as all the movements exceed the departures capacity: nb operations ICAO >> nb operations IPCC

    - Example: Ireland (Ryanair), Austria (EasyJet), Hungary (Wizzair)
- High differences for business jet country locations: nb operations ICAO > nb operations IPCC
    - Example: Monaco, Malta, Liechtenstein
- Difference for countries with lot of low-cost departures: nb operations ICAO < nb operations IPCC
    - Example: Greece, Italy

3 Impact on the action plan definitions

The choice of the method entails two significantly different approaches. The ICAO approach would bring the focus on the capability of a State to manage the emissions evolution of only its own "flag carriers". A State having a significant aviation activity operated by non-flag carriers would therefore not be able to reflect in the plan its possible policy on the evolution of its overall aviation activity. Also, if the State flag carriers have an important aviation activity between third countries, this would become a "responsibility" of the State in terms of emissions reduction plans.

The IPCC method, on the contrary, brings the focus on the management of the emissions reductions for the State related aviation activity, integrating the State's policy in terms of evolution and importance of the aviation business for it and national plans to reduce emissions (e.g., promotion of operations with more fuel-efficient aircraft).

Allowing States to use the ICAO or the IPCC method has the risk of under estimation for some as well as double counting for others if consolidating the States action plans.

It is also worth noting that the IPCC method actually allows consolidating and correlating the data with the CORSIA reporting. Indeed, under CORSIA emissions are reported by States aggregated at country pair level with no info on the operator. If all States were reporting action plans based on the IPCC approach aggregating at country pair level, this info can be consolidated and correlated with the CORSIA reported one. The ICAO method for the action plans would not allow this.

3.1 Impact on the baseline definition (ECAC)

The selection of the ICAO/IPCC method also affects the definition and estimation of the CO_2 emissions of the international flights at the ECAC level.

The Base year dataset and the forecasts dataset that EUROCONTROL shall define and assess (at the ECAC level), are based on the IPCC. The ICAO method cannot be used for such assessments.