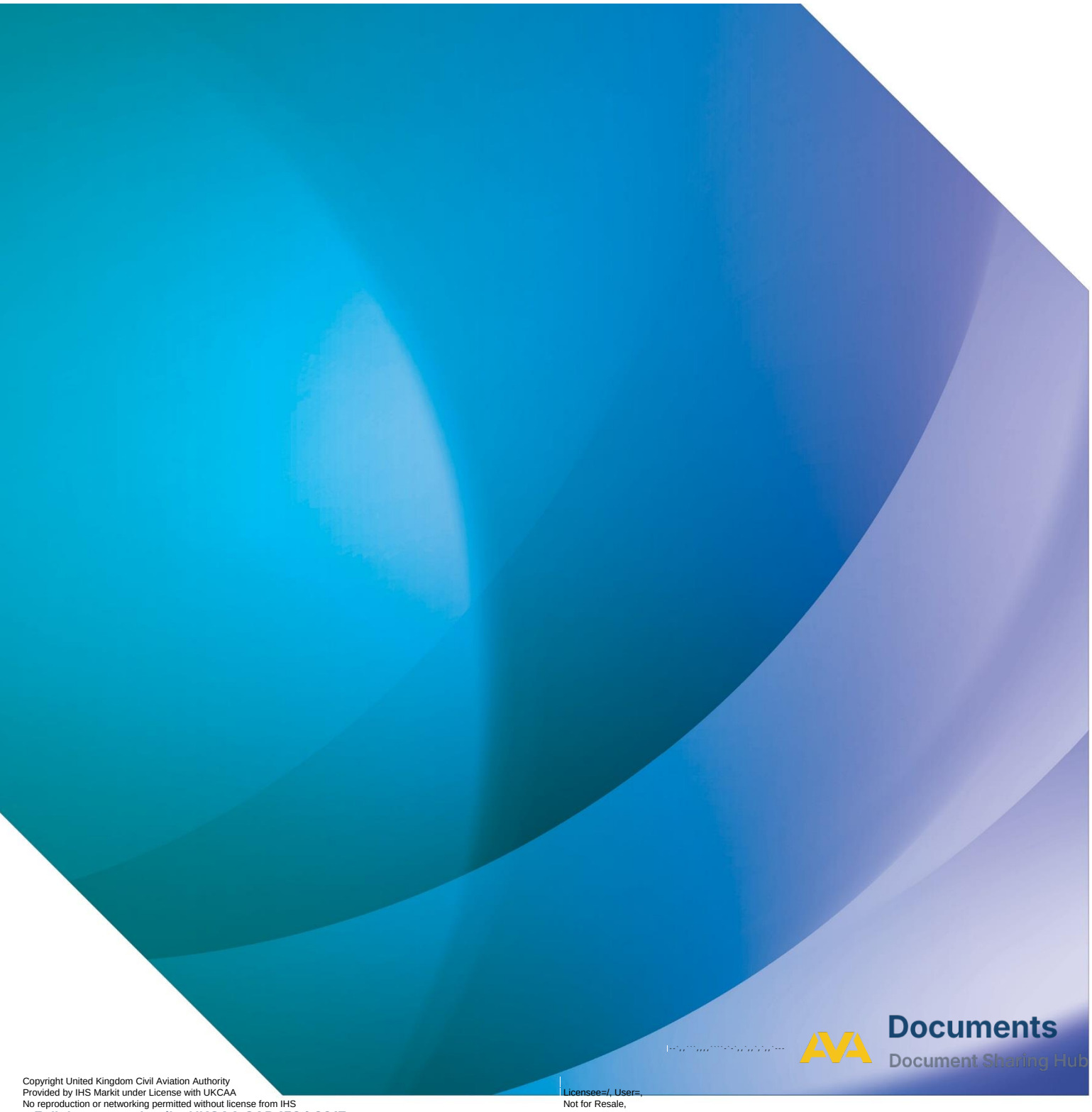
Information on aviation's environmental impact

CAP 1524



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Published by the Civil Aviation Authority, 2017

Civil Aviation Authority,

Aviation House,

Gatwick Airport South,

West Sussex,

RH6 0YR.

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First published 2017

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Introduction

Purpose

The purpose of this document is to bring together environmental information and data published on the CAA website between 2011 and 2014.

This data was initially presented with the intention of providing a ‘one stop shop’ for publicly available information on the environmental impact of the UK’s civil aviation activity.

As the CAA no longer considers this the most effective way of providing the public with environmental information, this data is no longer published on the CAA’s environment web pages and exists here in archive form.

In addition to specific figures on the environmental impact of airports, airlines and other bodies, this document also contains some high level explanations of how aviation affects the environment. Additionally, it provides more detailed explanation of how to interpret the relevant metrics of environmental impact than can be found on the CAA’s environmental web pages. While this information represented the most up to date thinking at the time it was published on the CAA website, we cannot ensure its continued accuracy.

General

The most common concerns around the environmental impact of aviation are climate change and noise, but air quality and local environments are also directly impacted by aviation.

Airlines and airports are not obliged to produce the data below, and while there are standard protocols (particularly around emissions) there are no standardised requirements for reporting. This makes it extremely difficult to produce comparable data, and users should be wary of drawing comparisons from the material in this document. In many cases the methodologies and time periods between entries are inconsistent, and users are advised to refer to source material from the airline or

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airport in order to understand the specific conditions under which their data was produced. More recent data, subsequent to that below, can also be found from the relevant airline/airport website.

This document will not be updated and no responsibility can be taken for the continued accuracy of any part.

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Chapter 1

Climate change

Introduction

Aircraft emit a range of greenhouse gases throughout different stages of flight. Aircraft are fairly unique in that they directly emit gases into the higher levels of the atmosphere. When emitted at this altitude, the same gases can have very different effects than when emitted at ground level.

Scientific evidence strongly indicates that these greenhouse gases contribute to climate change.

Greenhouse gases move throughout the atmosphere and so do not respect international boundaries. This means that they are an international issue regardless of where the emissions were released.

Types of greenhouse gases created by aviation

Many different gases contribute to climate change. CO2 is generally viewed as the most problematic greenhouse gas. It has a long life cycle and plays a key role in global warming. In aviation, it is primarily generated by burning carbon-rich 'fossil fuels' in engines. Other gases emitted by aircraft are:

- Oxides of nitrogen (NOx)
- Ozone (O3) – created by the reaction of NOx and sunlight
- Soot and aerosols
- Water vapour – causing contrail or man-made cirrus clouds

Less is known about the effects of these other gases. Some researchers predict that these gases have a far greater effect than CO2 when emitted in the higher levels of the atmosphere.

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Aviation's contribution to CO2 generation

The following table shows direct emissions from a number of sectors in 2012, according to data from the Committee on Climate Change:

Industry	Emissions (million tonnes per annum)
Power generation	150
Road transport	108
Industry	105
Aviation	34
Waste	22
Shipping	11

Table 1: Emissions by sector in 2012. Source: Committee on Climate Change

The Energy Savings trust estimated that the average house produces 4.5t of CO2 per annum. CO2 generation from aviation was therefore equivalent to 7.7 million homes in 2012.

CO2 emissions are directly proportionate to the amount of fuel burned by an aircraft. In approximate terms, every tonne of aviation fuel burned produces between 3.15 and 3.18 tonnes of CO2.

Aviation accounts for approximately 6% of total UK emissions. Of this, around 90% of these emissions arise from international flights; and 10% from domestic flights. Aviation emissions have doubled since 1990. Over the same time period, aircraft have become substantially more energy-efficient, through improvements in engine and airframe technology: but these improvements have not kept pace with the growth in emissions from increased air traffic. Because of continued increases in forecast demand for aviation and a lack of low carbon alternative technologies, aviation will increase its relative share of UK's emissions if greater improvements are not made.

Government has produced a series of aviation growth forecasts that predicts at what level CO2 emissions could be in the future. The Government forecasts have been reproduced in the table below and relate to emissions on all flights departing UK

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airports. The figures assume the central range forecast of an aviation sector that is constrained by available capacity.

2010 (actual)	2030 (forecast)	2050 (forecast)
33.2	43.5	47.0

Table 2: DfT UK aviation forecasts for CO2 emissions from flights departing UK airports (million tonnes)

It should also be remembered that activities associated with flying also create CO2 emissions. These can be:

- From airport buildings;
- Onsite ground vehicles; and
- From those travelling to the airport in vehicles whether to work at the airport or take a flight.

These activities constitute a relatively small proportion of total aviation emissions: the majority originate directly from aircraft. For example, in 2010 the direct emissions from major airports were less than 1% of the total emissions emitted by aircraft using the airports.

Climate change policies

In the UK, the Department of Energy & Climate Change (DECC) is responsible for delivering the UK Government's commitments under the Climate Change Act 2008. Under this Act, the UK is required to achieve an 80% cut in greenhouse gas emissions on 1990 levels by 2050. This applies to all sectors and is not specific to aviation.

The Government's target is to reduce UK aviation emissions so that by 2050 they are back to 2005 levels or lower. The Government has asked the Committee on Climate Change to suggest which emissions can be reduced and how. The Committee has also been asked to assess how further expansion in aviation beyond 2020 would affect the sector's ability to meet the Government target. The full report by the CCC is available on its website.

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In 2012 the CCC also recommended that emissions from international aviation should be included in the UK Carbon budget. However, due to the uncertainty over the international framework for reducing aviation emissions, this decision has been deferred by Government

Within the Aviation Policy Framework, the Government set out its expectation for aviation in relation to climate change – 'to ensure that the aviation sector makes a significant and cost-effective contribution towards reducing global emissions.' (2.4).

The policy framework goes on to say that 'Our emphasis is on action at a global level as the best means of securing our objective, with action within Europe the next best option and a potential step towards wider international agreement.' (2.5)

Within the European context, emissions from aviation are being tackled through the EU Emissions Trading System (ETS). The ETS regulates emissions in those sectors with the highest emissions such as power generation. The aviation sector became part of the scheme in 2012, and flight operators in the European Economic Area are required to submit data under the ETS.

The EU Commission publishes annual lists of emissions for those in the scheme.

At the international level, ICAO has agreed to targets for delivering carbon neutral growth from aviation from 2020 and delivering 2% annual emission improvements up to 2050. This will be achieved using a combination of improvements in technology, operational procedures, use of alternative fuels and the introduction of a global market based measure.

The ICAO General Assembly, through Resolution A38-18, agreed to develop this global market-based measure scheme for international aviation. The scheme that is being developed would be implemented from 2020. The design of this measure will require the agreement of the ICAO member states at the next ICAO General Assembly in September 2016.

More information can be found on this by visiting:

- The policy owner – The European Commission
- Responsibility for delivering EU-ETS policy within the UK – Department of Energy & Climate Change

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- The regulator for the EU-ETS – the Environment Agency

Factors contributing to aviation's CO2 emissions

There are many factors that affect the amount of CO2 emissions from a flight. Some of these are in the control of airlines; some can be controlled or influenced by airports and regulators; some are to do with the weather.

The main factors are:

- Aircraft type
- Flight profile and distance
- Weight of the aircraft
- Operational procedures
- Use of next generation biofuels
- The weather
- Efficiency improvements

Aircraft type

Each aircraft will burn fuel at a different rate. There can be variances between models: air frame design and modifications will affect drag and weight; different engines will operate at varying levels of efficiency depending upon the range that they are designed to fly. Between aircraft families the variances can be even greater.

Aircraft and engine manufacturers have significantly improved the efficiency of aircraft and engines since the early 1960s. Newer aircraft are in general more fuel-efficient and produce fewer emissions. While airlines obviously can control the age of their fleet, there is often a long lead time between order and delivery - meaning investments they make in fuel-efficient aircraft can take some time to make a difference to emissions performance.

Flight profile and distance

Aircraft burn fuel and emit emissions at differing rates during the different stages of a flight. These can be broadly categorised as:

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Take-off and climb to cruise altitude

There is a higher fuel burn rate at this stage because of the power needed to get the aircraft to climb to its cruise altitude. Air at a lower altitude is denser, creating more drag on the aircraft: at this stage the aircraft is at its heaviest because it holds all the fuel needed for the journey.

At cruise altitude

This is the most fuel-efficient stage of the flight because the air is less dense and the aircraft is flying at its most efficient operating speed.

Landing

At this stage the aircraft is at its lightest because it will have consumed most of its fuel load. The aircraft is also descending, requiring less power to be in operation, emitting proportionally lower emissions than at the start of the flight.

Efficiency and distance

Because of the high emissions at the start of a journey, short-haul flights are deemed the most inefficient because they spend a greater proportion of their total journey in the high emissions phase. These aircraft are also likely to do more short flights during a day, spending more time in the take-off and climb phase than longer haul aircraft.

Long-haul journeys are broadly speaking the next most inefficient type of flight. Although the aircraft spends a long time at its most efficient cruise altitude, the aircraft has to carry more fuel to cover the long distance and this extra weight makes it burn more fuel.

Medium distance flights of between 2,000 and 5,000 km are therefore the most fuel-efficient flights and tend to emit the lowest emissions per km travelled.

External factors

There are factors outside of an airline operator's control in relation to duration of flight. Very few flights can fly the most direct 'as the crow flies' route because of the need to safely manage aircraft traffic. In more congested airspace – such as above London and the South East of England – aircraft are often held in holding patterns or

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stacks before they are allowed to land. Airspace is also controlled for military purposes; and some airspace in the world is deemed not safe to fly over due to conflict on the ground which means greater distances have to be flown to avoid such areas.

Weather can also influence flight profiles – see below for further details.

Weight of the aircraft

The lighter an aircraft is, the less fuel it will burn. Reducing unnecessary weight on an aircraft can therefore reduce CO2 emissions (as well as fuel costs). Airlines are always looking for ways to reduce the weight of their aircraft, and have taken a wide range of steps to do so. These include:

- using lighter types of paint
- taking fewer and lighter catering trolleys on board
- removing in-flight magazines
- reducing the baggage allowance rates

Per flight, the level of emission saving is negligible. However, a Project Omega study found that if all these measures were taken on a single Boeing 747 (Jumbo Jet) that operated a daily return from the UK to the US, it would save 456.2 tonnes of CO2 per year. That's roughly equivalent to the average domestic carbon footprint of 45 UK residents.

Operational procedures

Changes to aircraft operational procedures both in the air and on the ground can reduce the amount of fuel they burn and hence the volume of CO2 they emit.

Continuous Climb Operations and Continuous Descent Operations aim to make the climb to or descent from cruising altitude more efficient. Just as in a car, smoother acceleration and deceleration burns less fuel, so a smoother, steadier climb with fewer changes of speed will require less aircraft fuel. A similar principle applies to descent, where a smoother descent, perhaps begun earlier, reduces the need for braking and re-acceleration.

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Clearly, this requires detailed flight planning and assistance from air traffic control. However, the aviation industry is looking to increase its use: industry body Sustainable Aviation has launched a campaign to increase the use of Continuous Descent Operations in the UK by 5%, which could reduce CO2 emissions by 10,000 tonnes a year. On the ground reduced engine taxiing and the use of Fixed Electrical Ground Power can also reduce the amount of fuel used. Further information can be found in relation to air quality in subsequent chapters.

Use of next generation biofuels

Conventional jet fuel, in common with other road transport fuels such as diesel and petrol, is based on fossil fuels and has a high carbon content - creating high levels of CO2 emissions. The aviation industry has looked at alternatives, such as biofuels (fuels derived from organic matter such as plants) which enable overall CO2 emissions to be reduced by taking account of the carbon absorbed during plant growth.

Early development of biofuels typically involved growing crops solely for fuel. However, it's now recognised that this approach can be environmentally counterproductive, because of the effects of land use change, competition with food crops and water supplies. Instead, there is a concerted effort to produce biofuels from waste sources.

Industry body Sustainable Aviation has published a roadmap outlining where the industry believes growth in biofuels can come from and what the barriers are to this growth.

The weather

The weather can worsen or improve the environmental impact on the environment from flight to flight:

- Headwinds will require more fuel to be burnt so increases emissions, although a tailwind will help reduce emissions.
- Bad weather such as snow, high winds or fog can cause delays with take-off and landing which see aircraft idling on the ground or being held in stacks which increases the emissions of the aircraft.

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- Temperature can result in higher and lower emission rates; with aircraft requiring less fuel to take off in colder temperatures due to the air being denser which enables the engine to run more efficiently.
- Indirect environmental effects can also occur from bad weather such as an increase in the amount of de-icing fluid needed to be used in prolonged spells of cold weather.

Efficiency improvements

In addition to reducing emissions levels overall, the aviation industry seeks to increase its efficiency. In environmental terms, this means reducing the level of emissions per passenger or tonne of freight carried.

Passengers make up a relatively small proportion of the total weight of an aircraft, but an aircraft is more 'efficient' when more passengers are carried as the total emissions are shared between larger numbers of people.

Consumer ability to reduce CO2 emissions

The easiest way to reduce CO2 emissions from flying is to reduce the amount you fly. This is not always practical: aviation is an important and convenient form of transport for millions of people.

Some steps can be taken to reduce emissions without ceasing to fly:

- Select airlines with modern (i.e. more efficient) aircraft
- Consider flying economy rather than business or first class
- Fly with airlines with lower CO2 performance figures
- Use public transport to get to the airport
- Make a carbon offset payment when you fly. This involves the payment of a sum to compensate for the emissions produced by a flight. Money from these schemes goes to projects working to reduce emissions. Some airlines offer a carbon offset charge when booking a flight, but specialist carbon offsetting companies are another option. Research your options. Information is available from the International Carbon Reduction and Offsetting Alliance.

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