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BRIEFING PAPER

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Aviation, decarbonisation and climate change

By David Hirst

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Contributing Authors:: POST Fellow Emily Mason authored the first draft of this briefing (as published in 2020). Subsequent revisions and edits have been made by Library Specialists
Noel Dempsey, Social and General Statistics

Summary

The aviation industry has been under long-term pressure to reduce its contribution to climate change – from governments, stakeholders and the public.

In 2019, domestic and international aviation accounted for around 8% of UK CO_2 equivalent emissions.

While the coronavirus pandemic has caused an unprecedented short term reduction in demand for air travel, many within the aviation industry expect demand to recover to 2019 levels by 2023-24 and to continue to grow thereafter.

Decarbonising aviation and "net zero": the challenge

Under the *Climate Change Act 2008* the UK is required to have net-zero greenhouse gas emissions by 2050. While the target does not explicitly cover emissions from international aviation and shipping, these emissions have been taken into account by setting aside "headroom" within the carbon budgets and the Committee on Climate Change has recommended that emissions from the UK's international aviation be formally included in the net-zero target.

However, aviation is widely recognised as both one of the most carbon-intensive forms of transport and one of the most difficult to decarbonise. This means that aviation could well be the largest contributor to UK greenhouse gas emissions by 2050, particularly if demand continues to grow.

Government policy and international initiatives

The Government is in the process of revising transport policy across all modes in order to meet the challenge of the 2050 net-zero emissions target. The Government intends to publish a transport decarbonisation plan and an aviation strategy (including a net-zero aviation strategy). It is also planning to publish an Aviation Recovery Plan to 'boost' air travel after the pandemic.

The UK Government, the EU and international bodies, and the aviation industry have proposed a number of initiatives to mitigate emissions from aviation, including:

- **Market-based measures** such as the United Nations CORSIA program, EU Emissions Trading System (EU ETS) and the UK ETS;
- **Measures to improve the fuel efficiency of conventional aviation** such as through changes to aircraft, air traffic management, airspace modernisation and ground operations at airports; and
- **Measures to promote the development and use of low carbon technologies** such as novel fuels (such as biofuels) and aircraft (such as hybrid-electric aircraft).

What about demand for flying?

There have also been calls for more action to limit the growth in demand for flying. Some have argued for new tax policies to discourage flying and for measures to influence individual consumer choices. At the 2020 Citizen's Assembly on Climate Change participants "resoundingly rejected" industry projections for a future in which air passenger numbers would rise by 65% between 2018 and 2050, saying that it would be "counter-productive" for tackling climate change.

1. Introduction

1.1 Greenhouse gas emissions from aviation

UK aviation greenhouse gas (GHG) emissions consist of:

- emissions from **domestic flights** within the UK, which **are included** in national emissions reduction targets under *Climate Change Act 2008* (including net zero by 2050); and
- emissions from **international flights departing from the UK**[1]. To date the UK's legally binding emissions reduction targets have **not formally included** such emissions but they have been taken into account by **setting aside "headroom"** within the carbon budgets.[2]

Reporting emissions from aviation

The UK Government's aviation emission reporting adheres to the Intergovernmental Panel on Climate Change's (IPCCs) 2006 Guidelines for National Greenhouse Gas Inventories. Emissions from aviation are calculated using fuel sales (referred to as 'bunker' fuel sales).[3]

The Civil Aviation Authority (CAA) has a duty under the *Civil Aviation Act 2012* to publish information about the environmental effects of civil aviation in the UK. Some airlines independently publish information on CO_2 emissions from journeys, including Ryanair.[4]

Through the EU Emissions Trading System (EU ETS, section 3.2) airlines flying within (but not to or from) the European Economic Area (EEA)[5] have been required to report their emissions since 2012.[6]

International Civil Aviation Organization (ICAO, the UN agency for aviation) members participating in the international offsetting scheme CORSIA (section 3.3) will also have to report their carbon emissions from 2021 as part of the offsetting scheme.[7]

Allocating international aviation emissions is a longstanding and contentious issue. One reason is that countries' carbon obligations, as part of international treaties, can vary significantly depending on how emissions are allocated. In 1996 the Subsidiary Body for Scientific and Technological Advice (SBSTA), an advisory body established under the UN Framework Convention on Climate Change (UNFCCC), considered eight allocation options in total, but ruled out four as impractical. The

1 This means flights to the UK are not included in national emissions reports.
2 Net zero in the UK, Commons Library Briefing Paper CBP-8590, 16 December 2019
3 There is some debate over the best methodology for measuring aviation emissions. However, as the vast majority of aircraft refuel each time they land, when recorded accurately, bunker fuel sales correlate closely with emissions (UK departing-flight emissions modelled by DfT are within 4% of the bunker fuel sales estimate). From: Net-zero and the approach to international aviation and shipping emissions: Letter from Lord Deben to Grant Shapps, Committee on Climate Change, 24 September 2019
4 RyanAir becomes first airline to publish monthly carbon emissions, BusinessGreen, 6 June 2019 (accessed on 20 February 2020)
5 EEA = the EU member states plus Norway, Liechtenstein and Iceland.
6 European Commission, Reducing emissions from aviation (accessed on 18 February 2020)
7 CORSIA Implementation plan (accessed on 18 February 2020)

four allocation options deemed practical involved allocating aviation emissions based on:

- the country where the fuel is sold;
- the nationality of airlines;
- the country of destination or departure of aircraft. Alternatively emissions could be shared by the countries of departure and arrival;
- the country of departure or destination of passenger or cargo. Alternatively, the emissions related to the journey of passengers or cargo could be shared by the countries of departure and arrival.

The UNFCCC decided to account for aviation emissions by asking countries to submit estimates based on bunker fuel use (see box). In 2019 the CCC noted that "the uncertainty attached to these estimates is no higher than for other sectors covered by carbon budgets" and therefore that this should be the approach for accounting for these emissions in the UK.

Emissions from international aviation are not directly included in the Paris Agreement – only domestic aviation emissions count towards Nationally Determined Contributions (NDCs). Instead, a sectoral approach (rather than state-by-state) is taken for mitigating emissions from international aviation. The Kyoto protocol delegated this responsibility to the UN specialised agency for aviation, the International Civil Aviation Organization (ICAO).[8]

In 2018, international and domestic (including military) UK aviation accounted for 7% (8% in 2019) of the UK's total greenhouse gas emissions – around 37.8 $MtCO_2e$, million tons of CO_2 equivalent.[9] This increased from 5% in 2005. Of this total, domestic aviation was responsible for 1.5 $MtCO_2e$ of GHG emissions, a decrease of 6% since 2017.[10] Globally, on average aviation accounts for 2-3% of greenhouse gas emissions.[11]

8 Shipping Aviation and Paris, UNFCCC, 18 May 2018 (accessed on 11 March 2020)
9 Final UK greenhouse gas emissions national statistics: 1990 to 2018, BEIS, 2020. Note: provisional statistics for 2019 have been released, however they are not yet broken down into different sectors, e.g. aviation. The full data release is expected in early 2021.
10 Final UK greenhouse gas emissions national statistics: 1990 to 2018, BEIS, 2020.
11 Reducing emissions from aviation, European Commission (accessed on 14 September 2020)

Policy on non-CO_2 warming from aviation emissions in the atmosphere

Alongside CO_2, aircraft emit other gases and particles (e.g. nitrogen oxides (NOx), water vapour, soot) at high altitudes that can affect atmospheric composition and cloudiness. A report commissioned by the Department for Transport (DfT) stated that these non-CO_2 effects comprise an estimated 50-60% of total warming from aviation emissions, i.e. they **double the CO_2 warming effect**. The uncertainties related to non-CO_2 warming are greater than those of CO_2 warming[12] and estimates of the contribution of aviation to carbon budgets **do not typically include these effects** (i.e. they may be underestimating the true effect aviation has on the climate).

Some indirect policies are already in place to limit some non-CO_2 effects due to their impact on air quality. These non-CO_2 effects are mainly short-lived, meaning that if the emissions causing them were to stop, their effects on climate would also rapidly disappear.[13]

In *Aviation 2050* the UK Government laid out their position on non-CO_2 effects:

> The government continues to support work on non-CO_2 emissions, their trade-offs with CO_2 and possible mitigation measures, **none of which are yet well enough understood to be able to form policy with confidence** that aviation's total climate impact would be reduced. The UK will continue working through ICAO on measures to regulate aircraft non-CO_2 emissions and ICAO is shortly expected to agree the first regulatory standard for aircraft non-volatile particulate (soot) emissions. The government proposes…to keep non-CO_2 emissions under review and reassess the UK's policy position as more evidence becomes available.[14]

The Government has also said that it **expected the ICAO to issue best practice guidance** on operational mitigations for non-CO_2 effects.[15]The ICAO has said that it does not yet include non-CO_2 effects in its Carbon Emissions Calculator but that it will review this in the future:

> The ICAO Carbon Emissions Calculator is limited to the calculation of the CO_2 amounts released into the atmosphere by the aircraft engines during a flight. Consequently, the ICAO Emissions Calculator does not quantify the climate change impact of aircraft emissions using the Radiative Forcing Index (RFI) or other such multipliers. The scientific community has not yet reached consensus on the use of the RFI or other such multipliers and therefore ICAO will only adopt a multiplier if and when the scientific community reaches a general agreement on this issue. ICAO is working in collaboration with IPCC [the Intergovernmental Panel on Climate Change] on this subject and will adapt a multiplier methodology in due course accordingly.[16]

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12 The current state of scientific understanding of the non-CO2 effects of aviation on climate, Manchester Metropolitan University, December 2018

13 The current state of scientific understanding of the non-CO2 effects of aviation on climate, Manchester Metropolitan University, December 2018

14 HM Government, *Aviation 2050 The future of UK aviation: A consultation*, Cm 9714, Dec 2018, para 3.95

15 HM Government, *Aviation 2050 The future of UK aviation: A consultation*, Cm 9714, Dec 2018, para 3.95

16 ICAO, Carbon Emissions Calculator FAQ (accessed on 11 March 2020)

Air passengers – who flies and why?

In the UK **air passenger numbers have nearly tripled over the last 40 years**: 104 million air passengers passed through UK airports in 1990; this had increased to 297 million in 2019.[17]

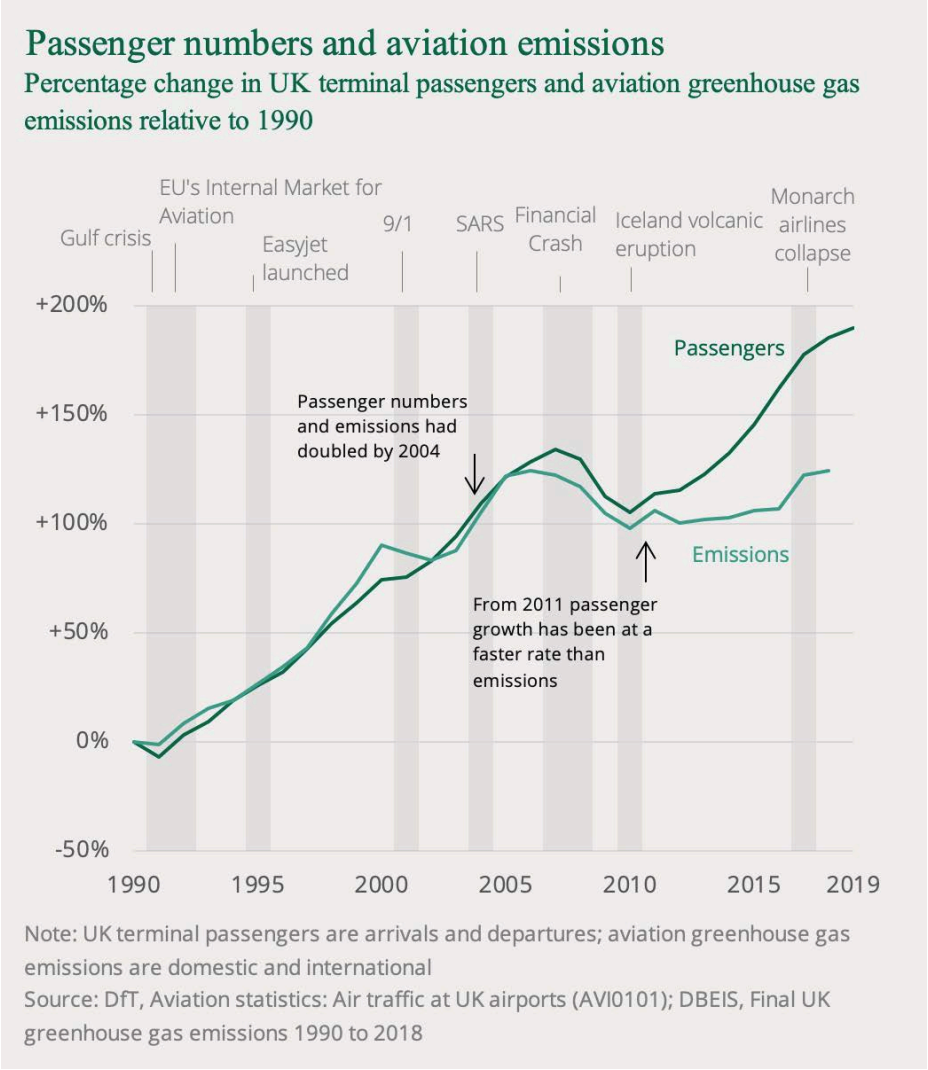
The majority of flights are taken by a small proportion of the population. In 2019 international and domestic flights made up around 12% of emissions from UK households (which also includes energy usage in the home, other forms of transport etc.) but this is unevenly distributed across the population and is growing.[18]A government survey of 1000 UK adults found that in 2013 70% of all flights were taken by only 15% of the population and 52% of people hadn't flown at all over the past year.[19] The National Travel Survey found that from a survey of 18,000 people in England, only 12% had flown three or more times in 2015.

Most journeys are made for leisure, not business. At UK airports in 2019, on average around 17% of passenger journeys surveyed were declared as being for business purposes. The remainder were declared are being for leisure reasons (i.e. holidays and visiting friends and family).[20]

17 UK airport data, CAA
18 Behaviour change, public engagement and Net Zero, Imperial College London, 10 October 2019, p16
19 Department for Transport, Public experiences of and attitudes towards air travel: 2014, 23 July 2014 (accessed on 14 September 2020)
20 Civil Aviation Authority: Departing Passenger Survey 2017 (accessed on 14 September 2020)

Future air travel demand growth

Over the last decade, CO_2 emissions from aviation and passenger numbers have decoupled, i.e. the rate of passenger number growth exceeds the rate of growth in emissions.[21] The aviation industry attributes this change to higher load factors (more passengers per



flight), increased fuel efficiency and greater demand for short-haul as opposed to long-haul flights.[22]

Despite this, predictions of continued growth and slow decarbonisation mean that the Committee on Climate Change (CCC), established by the *Climate Change Act 2008* as the independent advisory body on climate change, forecast that **aviation could be the largest single contributor to UK emissions by 2050**.[23]

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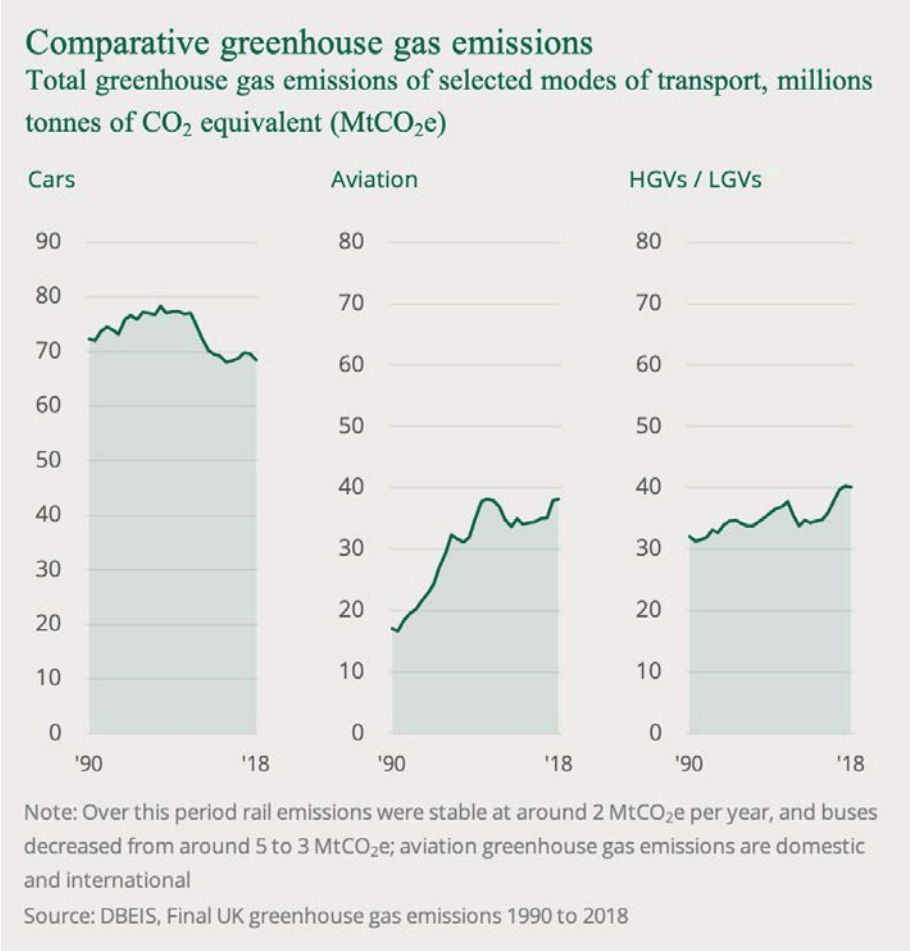
21 Air passenger numbers from the CAA Airport Data and emissions data from BEIS: Final UK greenhouse gas emissions national statistics.

22 HM Government, *Aviation 2050 The future of UK aviation: A consultation*, Cm 9714, Dec 2018, para 3.79

23 Net Zero – Technical Report, Committee on Climate Change, 2 May 2019



The CCC has said that "[in] the absence of a true zero-carbon plane, demand cannot continue to grow unfettered over the long-term". Their scenarios reflect a 25% growth in demand by 2050 compared to 2018 levels.[24] This is significantly lower than Government projections for up to a 49% increase in demand over the same period.[25] Both of these projections are significantly lower again than the UK aviation industry's claim that there are sufficient measures to support a 70% growth in passenger numbers by 2050 and still meet the a zero target.[26]

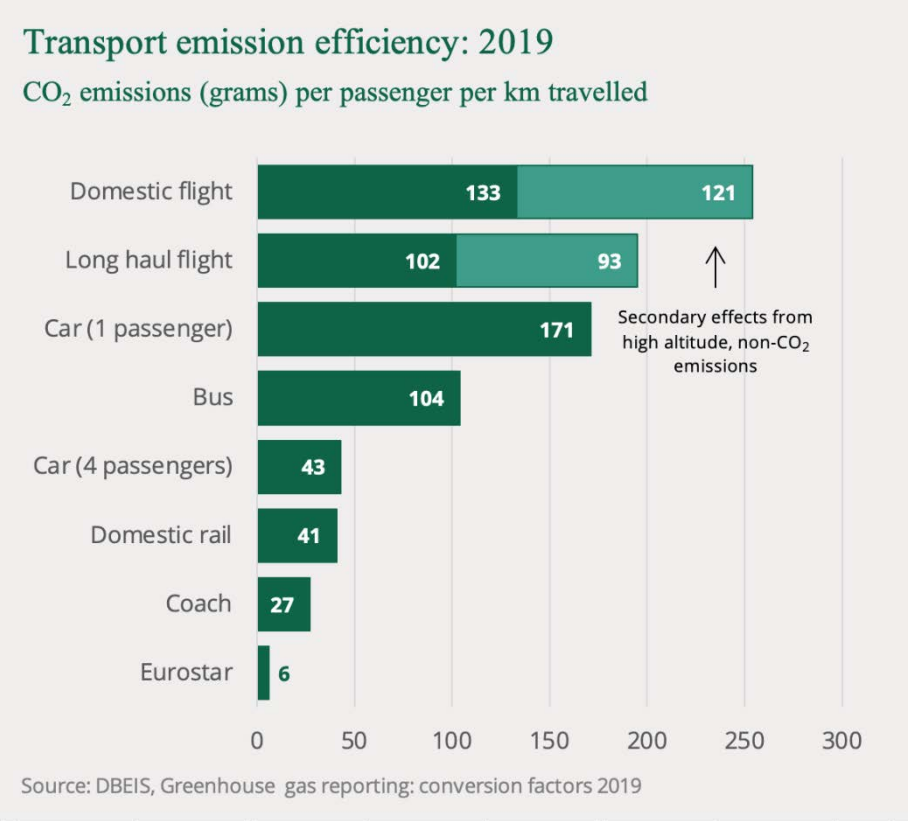
It is possible that aviation growth may exceed any of these predictions. In their high demand scenario forecast, the Department for Transport (DfT) predicts that between 2016 and 2050, long-haul and international short-haul air travel could grow by 127% and 84%, respectively.[27] The long-term impact of the coronavirus pandemic on air passenger numbers is not yet known. 2020 has likely seen a drop in GHG emissions of over 60% from 2019, due to the impact of COVID-19, with a return to pre-pandemic passenger levels not expected until 2024, according to analysis from the CCC.[28]

24 Net-zero and the approach to international aviation and shipping emissions: Letter from Lord Deben to Grant Shapps, Committee on Climate Change, 24 September 2019
25 UK Aviation Forecasts 2017, DfT, October 2017, para?
26 Decarbonisation Road-Map, Sustainable Aviation, 4 February 2020
27 UK Aviation Forecasts 2017, DfT, October 2017, para 6.11
28 CCC, The Sixth Carbon Budget: Aviation, December 2020

At the 2020 Citizens' Assembly on Climate Change, participants 'resoundingly rejected a future in which air passenger numbers would rise by as much as 65% between 2018 and 2050, labelling it as "counterproductive"'.[29]

1.2 Why is it difficult to decarbonise aviation?

It is widely accepted that aviation is a difficult form of transport to decarbonise,[30] particularly when considered in terms of the UK Government's timeframe for net-zero emissions by 2050.[31] Unlike some other forms of transport, such as cars and trains, there is no clear zero-emission alternative to fossil fuel-powered flight.



There are several reasons why air travel is uniquely difficult to decarbonise:

- **Air travel uses a lot of energy** and currently batteries are too heavy to support either commercial jet aircraft sizes or long distance services. Therefore, **electric flight is unlikely to be a significant feature of commercial aviation before 2050**.[32] Long-haul routes are unlikely to be replaced by electric or hybrid-electric planes in the foreseeable future.[33]

29 *The Path to Net Zero*, Climate Assembly UK, September 2020, p 16
30 Decarbonising Aviation. Plane easy? ECIU, 24 September 2019 (accessed on 19 February 2020)
31 Net zero in the UK, Commons Library Briefing Paper CBP-8590, 16 December 2019
32 Net zero in the UK, Commons Library Briefing Paper CBP-8590, 16 December 2019
33 Carbon-neutral flying already technically feasible, says German transport expert, EURACTIV, 4 November 2019 (accessed on 18 February 2020)

- **Low-carbon fuels**, which provide a 'drop-in' replacement for fossil fuel-derived kerosene (jet fuel), are only in the **early stages of development and are still too expensive** to compete with conventional jet fuel. Also, they are not yet produced in sufficient quantities to provide a feasible replacement.[34] Aviation will also be competing with other sectors for access to biofuels. The CCC suggest that the aviation sector might not be the best place to use the UK's biofuels resources and that they might be better used in BECCS (bio-energy with carbon capture and storage), for example.[35]
- The **longevity of the fleet** means that it takes longer for air transport companies to introduce newer, more sustainable aircraft into service. This can be compounded by the time it takes aircraft to pass rigorous national and international safety standards.[36] The **coronavirus pandemic** has meant that some airlines have retired aircraft earlier than expected. This could help reduce emissions if they are replaced by new more efficient aircraft faster than expected.
- In 2018, 96% of UK emissions from aviation were from international flights.[37] This makes international cooperation critical and both the CCC and the UK Government have said that a priority needs to be placed on **international measures to reduce the climate impact of the aviation industry**.[38] There is ongoing criticism of slow international negotiations on this issue and the resulting global aviation carbon offsetting scheme (CORSIA, see section 3.3), which has been called 'unambitious'.[39]

1.3 Economic and social impacts of aviation

This paper does not discuss at length the debates surrounding aviation growth, but it is worth briefly providing some context as to why the Government believes that the UK needs to retain a thriving aviation sector, while acknowledging that it wants aviation to play its part in achieving net zero.

Benefits to the UK economy

The UK Government's green paper on aviation strategy, *Aviation 2050*, describes its reasons for supporting sustainable aviation growth:

> The Government has been clear about the importance of aviation to the whole of the UK. Aviation creates jobs across the UK, encourages our economy to grow and connects us with the rest of the world as a dynamic trading nation. It also helps maintain international, social and family ties. This is why the Government supports the growth of aviation, provided that this is done in a

34 Low-carbon aviation fuels, POSTnote 616, 24 February 2020
35 Owen Bellamy, Committee on Climate Change, Climate Assembly, 9 February 2020
36 Owen Bellamy, Committee on Climate Change, Climate Assembly, 9 February 2020
37 Final UK greenhouse gas emissions national statistics: 1990 to 2018, BEIS, 2020.
38 HM Government, *Aviation 2050 The future of UK aviation: A consultation*, **Cm 9714**, Dec 2018, para 3.82
39 Corsia: The UN's plan to 'offset' growth in aviation emissions after 2020, Carbon Brief, 4 February 2019 (accessed on 19 February 2020)

> sustainable way and balances growth with the need to address environmental impacts.[40]

Aviation directly contributes at least £22 billion to the UK economy annually, with around £14 billion from air transport and £8 billion from aerospace. In 2017 the UK aviation industry transported 2 million tonnes of freight[41] and exported £85 billion of goods by air to extra-EU countries – this represents 47% of all extra-EU exports in value for that year.[42] In 2017, the aviation industry was estimated to directly provide 230,000 jobs (note that the coronavirus pandemic has led to many job cuts in aviation – see section 1.4).[43]

What are the costs of achieving net-zero by 2050?

In November 2019 the Treasury announced that it was conducting a review into funding the transition to a net zero economy, which they intend to publish in autumn 2020.[44] Some MPs have also called for an independent review. For example, on 10 February 2020 a Private Members Bill was presented to the Parliament calling for an "independent audit of the costs and benefits of meeting the requirement under the Climate Change Act 2008 for net United Kingdom carbon emissions to be zero by 2050; and for connected purposes".[45]

On 17 December, the Treasury published interim findings. The six key interim findings are:

1. The combined effect of UK and global climate action on UK economic growth is likely to be relatively small. The scale, distribution and balance of new growth opportunities and challenges will depend on how the economy and policy respond to the changes required.
2. The costs of the transition to net zero are uncertain and depend on policy choices.
3. Government needs to use a mix of policy levers to address multiple market failures and support decarbonisation
4. Well-designed policy can reduce costs and risk for investors, support innovation and the deployment of new technologies.
5. The risk of carbon leakage will increase with efforts to reduce emissions.
6. Households are exposed to the transition through their consumption, labour market participation and asset holdings. Government needs to consider these patterns of exposure in designing policies for the transition.[46]

Growth in passenger numbers in the past 30 years has been dominated by London airports (London Gatwick, Heathrow, City, Luton, Southend and Stansted).[47] While recognising the benefits of aviation for the UK

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40 HM Government, *Aviation 2050 The future of UK aviation: A consultation*, **Cm 9714**, Dec 2018, para 1.2
41 UK airport data, CAA
42 HM Government, *Aviation 2050 The future of UK aviation: A consultation*, **Cm 9714**, Dec 2018, p19
43 HM Government, *Aviation 2050 The future of UK aviation: A consultation*, **Cm 9714**, Dec 2018, p21
44 HM Treasury, Net Zero Review: terms of reference, 2 November 2019
45 Net Zero Carbon Emissions (Audit) Bill 2019-21
46 HM Treasury, *Net Zero Review: Interim report*, Dec 2020
47 UK airport data, CAA. The dominance of London airports has somewhat decreased over the last 40 years, from 66% in 1990 to 61% in 2018. The dominance of

generally, some MPs have sought assurance from Government that the focus of future expansion should not focus solely on London at the expense of regional airports.[48] In January 2020 the Government announced its intention to conduct a regional air connectivity review.[49]

Aviation: passengers vs freight

Passenger flights account for 97% of UK aviation CO_2 emissions, with many of these passenger flights carrying freight in the hold. The other 3% is assumed to be accounted for by dedicated freight-only flights.[50]

Figures show that freight carried to and from UK airports by dedicated cargo aircraft declined by 10% between 2005 and 2018, while over the same period, freight carried in the hold of passenger aircraft increased by over 23%. Overall UK air freight volumes rose by 11% between 2005 and 2018 with most of this growth occurring from 2014.[51]

International trade, business and tourism

The UK has direct connections to over 370 destinations in more than 100 countries worldwide. While business travel generally represents less than 30% of passenger journeys at UK airports, the Government states in *Aviation 2050* that: "industries most associated with business travellers generate some of the largest contribution to the UK economy due to the high value of the industries they tend to work in."[52] It is unclear how the recovery from the pandemic will shape the future of business travel demand due to behaviour change (e.g. due to video-conferencing).

Tourism contributed £68 billion to the UK economy in 2016 and inbound tourism by air made up 80% of foreign holiday spending.[53] The aviation industry argues that international tourism (facilitated by air travel) provides significant social and economic benefits.[54]

The low-cost air travel 'revolution'

When commercial air travel was first introduced in the early 1900s, it was a luxury that only the wealthiest could afford. However in the 1980s and 1990s this began to change, helped along in Europe by the liberalisation of EU airspace in 1992 under the Single European Act. So-called 'no frills' airlines such as easyJet and Ryanair brought down ticket prices.[55]

In 2007 the Transport committee summed up the democratising power of 'no frills' flying:

London airports reached its lowest point since 1990 in the lead up to and during the financial crisis (58% from 2005 to 2008.

48 e.g. Hansard HC (2 March 2020) Volume 672 Column 632 Airport Expansion

49 Government announces measures on regional connectivity, *gov.uk*, 15 January 2020 (accessed on 12 March 2020)

50 Decarbonisation Road-Map, Sustainable Aviation, 4 February 2020, p15

51 Decarbonisation Road-Map, Sustainable Aviation, 4 February 2020, p74

52 HM Government, *Aviation 2050 The future of UK aviation: A consultation*, **Cm 9714**, Dec 2018, p21

53 Travel trends estimates: overseas residents in the UK, Office for National Statistics

54 Social and economic benefits of aviation, ATAG (accessed on 20 March 2020)

55 Simon Calder, No Frills: The Truth Behind the Low Cost Revolution in the Skies (2006)

> There is no doubt that low cost airlines have been in their way one of the strongest democratic forces of the past decade or so. UK citizens on low and fixed incomes can today travel to mainland Europe for as little as £20 or £30, something they could not have dreamed of a quarter of a century ago.[56]

The low-cost air travel revolution has undoubtedly played a role in increasing emissions from aviation over the last few decades. Although there has been progress in opening up air travel to more people, in 2013 **only 15% of people took 70% of flights in the UK**.[57] At the 2020 Citizens Assembly on Climate Change, participants indicated a desire to address this imbalance. They said that while any solution to tackling the climate impact of air travel should "take account of different travel needs [i.e. seeing family abroad]", "frequent fliers and those who fly further should pay more"[58] – see section 5 for more detail.

1.4 The impact of the coronavirus pandemic

The coronavirus pandemic caused an unprecedented collapse of air passenger volumes, huge financial losses and sweeping job cuts for aviation. The full impact on aviation is not yet known.

The ICAO predicts an overall reduction of in passenger numbers for 2020 of 2.6–2.9 billion (compared to 2019), and a US$355–392 billion potential global loss of gross passenger operating revenues. These losses are likely to stretch well into 2021 and many airline chiefs have said they do not expect a full recovery for their businesses until at least 2023-24. This recovery is much slower than that seen in previous pandemics. Job cuts have also been announced across the industry – estimates in mid-September 2020 suggest over 33,000 UK job cuts in aviation had been announced. Industry portal Cirium estimates that by late April 2020 almost 64% of the global fleet was grounded.

Demand for air travel is recovering at different rates globally. By mid-August 2020, jet fuel consumption in China had recovered to 60% of 2019 levels, compared to 43% for the US and 36% for Europe. In both the US and China, recovery has been partly attributed to their large domestic markets, where air travel is increasing faster than in international markets.

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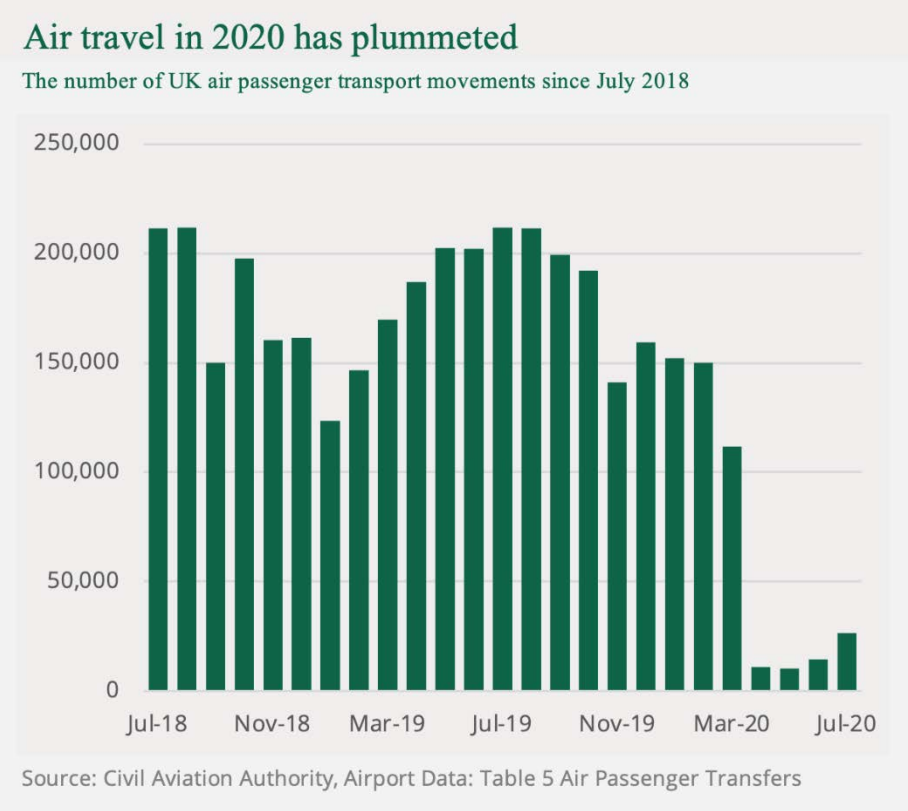
56 Transport Committee, Passengers' experiences of air travel (eighth report of session 2006-07), HC 435, 26 July 2007, para 129

57 Do 15% of people take 70% of flights?, fullfact.org, 25 November 2016 (accessed on 14 September 2020)

58 *The Path to Net Zero*, Climate Assembly UK, September 2020, p 17

The pandemic fundamentally changed the way business was conducted as many companies had to move their interactions online. Some commentators have suggested that this could have a long-term impact on demand for business travel.



2. International and domestic policy on emissions mitigation in aviation

Aviation is by nature an international industry. For example, in the UK in 2018 international aviation accounted for 96% of total UK aviation greenhouse gas emissions.[59] International aviation is predominantly privately funded and operated, though there is a great deal of variation in terms of airport ownership and public support to airlines and for specific routes. For example, while virtually all the airports in the UK are privately owned and financed, that is not the case in the United States or in many European countries.[60]

Due to the complex and global nature of the industry, mitigation of emissions from international aviation is mostly **governed by international regulations** agreed at the UN level and, in Europe, at EU level.[61]

At a global scale, climate change mitigation is shaped by the international treaties. The UK is a Party to the UN Framework Convention on Climate Change (UNFCCC) and has signed and ratified the Paris Agreement: an international agreement on climate change. The key aim of the Paris Agreement is to hold the increase in the global average temperature to well below 2°C above pre-industrial (1850–1900) levels and pursue efforts to limit the temperature increase to 1.5°C. The Agreement also included a widely acknowledged net zero global greenhouse gas emissions aim for the second half of the 21st century.[62] International aviation emissions however are not reported under the Paris Agreement, and these emissions are not included in a country's Nationally Determined Contributions.[63]

The UK Government has played a key role in shaping many of these international policies and provides some support to initiatives to mitigate emissions from aviation through for example, technology and operational developments (see section 4).

2.1 International policy

In Europe, aviation emissions have been included in the **EU Emissions Trading System** since 2012 (see section 3.2).

At the **UN level,** responsibility for mitigating emissions from international aviation lies with the International Civil Aviation Organization (ICAO).

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59 Final UK greenhouse gas emissions national statistics: 1990 to 2018, BEIS, 2020
60 Study on airport ownership and management and the ground handling market in selected non-EU countries, Steer Davies Gleave, June 2016
61 The Future of Mobility, GO Science, January 2019, p28
62 Net zero in the UK, Commons Library Briefing Paper CBP-8590, 16 December 2019
63 Shipping Aviation and Paris, UNFCCC, 18 May 2018 (accessed on 11 March 2020)

ICAO has agreed on **two 'aspirational goals'** for the international aviation sector:

- 2% annual fuel efficiency improvement through 2050
- Carbon neutral growth from 2020 onwards (CNG 2020)[64]

It aims to achieve this through a so-called **'basket of measures'** including:

- Aircraft related technology [see sections 4.3 and 4.4] and standards [see Aircraft emissions standards, below]
- Improved air traffic management and operational improvements [see section 4.2]
- Development and deployment of sustainable aviation fuel [see section 4.1]
- CORSIA[65] [see section 3.3]

ICAO has also stated that it is considering a **long-term climate goal**. At the 40th ICAO assembly members discussed the possibility of this goal, which could be in line with the International Air Transport Association (IATA) long-term goal to halve net aviation CO_2 emissions by 2050 compared to 2005 levels.[66]

Commentators expect that **uptake of sustainable aviation policies will vary globally**. For example, Boston Consulting Group anticipate that Europe will continue to take some of the 'boldest steps' to regulate aviation, while governments in Asia could follow (four airports in India are already carbon neutral, although India is not fully participating in ICAO mitigation measures, see section 3.3). They expect the US to remain reluctant to take any major regulatory action.[67]

In *Aviation 2050*, the Government said that it was "committed to setting a clear and appropriate level of ambition for the [aviation] sector. In doing so, the government recognises that international action is the first priority for tackling international aviation emissions".[68]

To this end it proposed to:

> …negotiate in ICAO (the UN body responsible for tackling international aviation climate emissions) for a long-term goal for international aviation that is consistent with the temperature goals of the Paris Agreement, ideally by ICAO's 41st Assembly in 2022.[69]

64 CORSIA Implementation plan (accessed on 18 February 2020)
65 CORSIA Implementation plan (accessed on 18 February 2020)
66 Call for long-term aviation emissions target, CORSIA support, and new CAEP supersonics study among key environmental protection outcomes at 40th ICAO Assembly, ICAO, 8 October 2019 (accessed on 18 March 2020)
67 Seven Trends That Will Reshape the Airline Industry, BCG, 9 January 2020 (accessed on 26 February 2020)
68 HM Government, *Aviation 2050 The future of UK aviation: A consultation*, **Cm 9714**, Dec 2018, para 3.82
69 HM Government, *Aviation 2050 The future of UK aviation: A consultation*, **Cm 9714**, Dec 2018, para 3.83

Aircraft emissions standards

In March 2017, ICAO adopted a CO_2 emissions standard for aircraft.[70] The ICAO standard will apply to new aircraft types from 2022, modified existing types from 2023, and unmodified existing aircraft types from 2028. By 2028, aircraft in-production that do not meet the standard will have to be redesigned. However, as aircraft remain in service for 20-30 years[71], many aircraft already in use that do not meet the standard will remain in circulation beyond 2028.[72]

The UK Government has said that it will:

> … negotiate in ICAO for standards for all engine emissions with climate effects. As scientific understanding improves, the government will expect ICAO to issue best practice guidance on operational mitigations for non-CO_2 effects.[73] [see box: Policy on non-CO_2 warming from aviation emissions in the atmosphere, above]

2.2 UK Government policy and strategy

UK policy on all forms of transport is undergoing changes as the Government prepares to meet the challenge of net-zero emissions by 2050. Before the UK hosts COP26 in Glasgow on 1-12 November 2021, the UK Government is expected to publish a new **transport decarbonisation plan** and its **final aviation strategy White Paper.** Additionally, the Government has said it would publish an **Aviation Recovery Plan**, which would map out a green recovery from the pandemic.

Net zero and international aviation emissions

In June 2019 the Government legislated for the UK to reach net-zero emissions by 2050, by amending the *Climate Change Act 2008*. This includes a set of 'targeted greenhouse gases', including but not limited to: carbon dioxide, methane, nitrous oxide and fluorinated gases. As mentioned in section 1.1, currently only domestic flights are explicitly included in the legislation, while emissions from international aviation are taken into account by setting aside "headroom" in carbon budgets.[74]

No other nations currently include international aviation and shipping emissions in their net-zero targets and/or strategies. Scotland has included them in their targets,[75] but some have suggested that

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70 Q&A: The ICAO CO2 Standard For Aircraft, ATAG, February 2016
71 How Are Planes Decommissioned, and How Much Value Can Be Salvaged From Their Parts? flexport.com, 12 April 2016
72 ICAO Council adopts new CO2 emissions standard for aircraft, ICAO (accessed on 4 March 2020)
73 HM Government, *Aviation 2050 The future of UK aviation: A consultation*, **Cm 9714**, Dec 2018, para 3.96
74 UK becomes first major economy to pass net-zero emissions law, *gov.uk*, 27 June 2019 (accessed on 19 February 2020)
75 Reducing greenhouse gas emissions, *gov.scot* (accessed on 21 February 2020)

increasing aviation emissions contributed to Scotland missing its emissions target in 2017.[76]

In September 2019 the Chair of the CCC, Lord Deben, responded to a request for advice on international aviation emissions and net zero. Lord Deben and the CCC advised the Government that:

- international aviation emissions should be formally included in the net zero 2050 target.[77]
- while international policies should be the priority, this should not prevent the inclusion of emissions from international aviation in UK carbon targets.[78]

In *Aviation 2050* the Government says that it aims to "develop a partnership for sustainable growth which meets rising passenger demand, balanced with action to reduce environmental and community impacts".[79] It also proposed to "accept the CCC's recommendation that emissions from UK-departing flights should be at or below 2005 levels in 2050".[80] Further, in March 2020 the Government indicated that their *Transport Decarbonisation Plan* would contain a contingency "to include international aviation and shipping emissions in our carbon budgets if there is insufficient progress at an international level"[81]

On 4 February 2020 the UK aviation industry consortium, Sustainable Aviation, published a road-map to voluntarily bring all international flights departing the UK into the net-zero target by 2050 (whilst also allowing 70% growth in air passenger numbers).[82]

Further discussion of the UK carbon budgets and the *Climate Change Act 2008* (as amended) is set out in the Commons Library Briefing on UK Carbon Budgets (2019) and the Library Briefing on Net Zero in the UK (2019).

Aviation 2050

In 2018, the Government set out its draft strategy for the aviation sector, *Aviation 2050*. The final Aviation 2050 White Paper was expected in 2020, but has been delayed due to the ongoing coronavirus-pandemic. The Government is also expected to publish an

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76 Scotland missed 2017 climate change target, new figures show, energyvoice.com, 12 June 2019 (accessed on 15 September 2020)

77 Net-zero and the approach to international aviation and shipping emissions: Letter from Lord Deben to Grant Shapps, Committee on Climate Change, 24 September 2019

78 Net-zero and the approach to international aviation and shipping emissions: Letter from Lord Deben to Grant Shapps, Committee on Climate Change, 24 September 2019

79 HM Government, *Aviation 2050 The future of UK aviation: A consultation*, **Cm 9714**, Dec 2018, para 1.21

80 HM Government, *Aviation 2050 The future of UK aviation: A consultation*, **Cm 9714**, Dec 2018, para 3.87

81 Department for Transport, *Decarbonising Transport: Setting the Challenge*, para 2.58.

82 Decarbonisation Road-Map, Sustainable Aviation, 4 February 2020

aviation recovery plan[83]; the Transport Committee says the plan "cannot come quick enough".[84]

In the draft strategy, the Government said it would:

> … consider the use of all feasible abatement options [to tackle aviation emissions], particularly in-sector measures, to ensure effective action is taken at the national and international level. This includes policies that may evolve over the long term such as technological developments, operational efficiencies, sustainable fuels, market-based measures, demand management and behavioural change[85]

However, when the *Aviation 2050* green paper was published, it was criticised by the Confederation of British Industry who said that it "does not do enough to practically set out how the UK will increase its global connectivity whilst meeting its sustainability targets".[86]

Further information on the Government's policies is provided in sections 3 (Market-based measures), 4 (Technology and operations) and 5 (Demand management and behavioural change) of this paper.

Devolution and aviation

Scotland, Wales and Northern Ireland all have a much smaller share of residual emissions from aviation compared to the UK overall due to the dominance of London airports. Ninety per cent of all UK air passengers travel through airports in England, with English airports acting as a hub for long-haul flights for passengers from all the nations of the UK.[87]

Domestically, policy on air travel and airports is largely reserved to the UK Government, but some aspects are devolved to Scotland, Wales and Northern Ireland, particularly as regards to noise pollution and control. So, for example, the UK Government sets the overall strategy for airspace use and management, and how airports are regulated, but the Scottish Government could impose different noise restrictions on airport operations in Scotland. The Scottish and Welsh Governments also own an airport each (Glasgow Prestwick and Cardiff respectively). Air Passenger Duty (APD) – a tax on flying – is devolved in Scotland and partially devolved in Northern Ireland.[88]

Reducing emissions from aviation: competitiveness and carbon leakage

Concerns about the UK taking unilateral domestic action in mitigating/reducing emissions from aviation include that it could lead to **carbon leakage** and a negative impact on the UK's **competitiveness**:

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83 "Beyond the crisis" - speech to the aviation industry, 19 Oct 2020

84 Transport Committee, Government aviation recovery plan cannot come quick enough for stricken sector, 7 Sept 2020

85 HM Government, *Aviation 2050 The future of UK aviation: A consultation*, **Cm 9714**, Dec 2018, para 3.96

86 Government's Aviation Strategy "misses the mark" on sustainability and growth, CBI, 26 June 2019 (accessed on 14 September 2020)

87 Net Zero – Technical Report, Committee on Climate Change, 2 May 2019, p166, 170

88 Transport in Scotland, Wales & Northern Ireland, Commons Library Briefing Paper CBP-SN03156, 12 June 2017

- Firstly, on **carbon leakage**, if an emissions mitigation policy is applied unilaterally (i.e. by only one country or region), emissions outside that region might increase. This is because companies and individuals affected by the policy might move their business overseas, or adjust their business practices in a way that prevents emissions from being reduced overall. While domestic targets might be achieved, overall global emissions might not be reduced by policies that lead to carbon leakage.[89]
- **Competitiveness** can be defined in a number of ways but the appropriate definition in the context of aviation is the ability of companies in a region to maintain profits and market share.[90] Unilateral policies might disproportionately affect businesses operating in that region, and this may lead to a competitive disadvantage. The Government has typically supported international policies for multilateral aviation emissions reductions for this reason.[91]

The CCC has highlighted three policies that could be applied at the UK level with limited competitiveness risks (i.e. without disadvantaging the UK compared to our neighbours):

- support for developing alternative fuels;
- managing growth in demand; and
- kick-starting a market for Greenhouse Gas Removals (GGRs).[92]

The Government provides support for the development of alternative fuels for aviation (also known as sustainable aviation fuels, see section 4.1) and for some types of GGRs (see section on Greenhouse gas removals, below).

Research commissioned by the DfT in 2018 on carbon leakage and competitiveness has found:

- Changes to airline behaviour (e.g. mandated biofuel uptake or landing charges based on aircraft fuel efficiency) usually led to carbon leakage
- Changes to passenger behaviour (e.g. demand reduction through an increased carbon price) usually did not.[93]
- Overall impact of passengers switching to different connecting airports (or 'hubs') outside the UK would be small compared to the impact on journeys starting and ending in the UK.[94]

89 The Carbon Leakage and Competitiveness Impacts of Carbon Abatement Policy in Aviation, ATA Ltd and Clarity Ltd, November 2018
90 Julia Reinaud, Issues behind competitiveness and carbon leakage, IEA Information Paper, 2008
91 Secretary of State for Transport, *Aviation Policy Framework*, **Cm 8584**, March 2013
92 Net-zero and the approach to international aviation and shipping emissions: Letter from Lord Deben to Grant Shapps, Committee on Climate Change, 24 September 2019
93 The Carbon Leakage and Competitiveness Impacts of Carbon Abatement Policy in Aviation, ATA Ltd and Clarity Ltd, November 2018
94 The Carbon Leakage and Competitiveness Impacts of Carbon Abatement Policy in Aviation, ATA Ltd and Clarity Ltd, November 2018

- The extent of competitive disadvantage for UK airlines and airports depends on the balance of passenger and airline response to a given policy:
  - Carbon price increases and mandated biofuel uptake are expected to have roughly the same impact on UK and non-UK airlines operating on UK routes.
  - Changes in landing charge could disadvantage UK airlines.[95]

[95] The Carbon Leakage and Competitiveness Impacts of Carbon Abatement Policy in Aviation, ATA Ltd and Clarity Ltd, November 2018

3. Market-based measures (MBMs)

3.1 An introduction to MBMs and offsetting

Market-based measures (MBMs) are instruments designed to address the climate impact of aviation, beyond what operational and technological measures or sustainable aviation fuels can achieve.

Since the aviation industry will rely on market-based measures (MBMs, see sections 3.2 and 3.3) and offsetting to meet their emissions reduction goals, it is worth briefly explaining how these measures work and the wider context of MBMs in overall climate goals.

Carbon markets support international climate change efforts by acting as a source of finance and allowing access to cost-efficient abatement mechanisms.[96] The rules for use of carbon markets in mitigating emissions are laid out in Article 6 of the Paris Agreement. Article 6 rules have not yet been fully agreed, with some important decisions remaining for COP26 in Glasgow. For more information see Commons Library briefing: Chile Madrid climate change conference: COP25 (2019)

Broadly, there are two types of carbon market:

- **Cap-and-trade** schemes (or *emissions trading systems*, *ETS*), such as the EU ETS (see section 3.2), and the soon-to-be UK ETS. Companies trade emissions allowances which allow them to emit one tonne of CO_2e. These allowances are then 'surrendered' to the governing body of the scheme.
- **Baseline-and-credit** mechanisms (or more simply, offsetting mechanisms). Countries/companies trade offsets, i.e. emission reduction units, which represent *one tonne of CO_2e which has been reduced already*.[97] The UN's Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA, see section 3.3) takes this approach.

For aviation, the main MBMs currently in place are the EU ETS and CORSIA (Carbon Offsetting and Reduction Scheme for International Aviation).

Offsetting

The international aviation industry (through ICAO) agreed in 2013 that MBMs, which often include the use of offsetting, would play an important role in mitigating emissions from aviation.[98]

Carbon offsetting is the process of purchasing carbon credits to 'offset' carbon emissions, resulting in net-zero emissions. Offsetting can be done at an individual level (e.g. offsetting emissions from personal air travel), or by businesses and industries. Countries/regions may also

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96 How to price carbon to reach net-zero emissions in the UK, Joshua Burke, Rebecca Byrnes and Sam Fankhauser, May 2019

97 Note that sometimes, offsets can be used in emission trading systems.

98 Market-Based Measures, EASA (accessed 17 March 2020)

engage in offsetting to meet their climate goals. The efficacy of offsetting measures has been the subject of ongoing debate.[99]

In July 2019, the UK Government opened a call for evidence on carbon offsetting in transport. The call for evidence focused on options for individual passengers to offset their own emissions. The consultation closed in September 2019.[100]

For commercial aviation it proposed two options for the provision of environmental consumer information:

- CO_2 emissions produced per passenger for an individual journey;
- Information on the level of CO_2 emissions produced by different models/ages of aircraft.[101]

The Government suggested that any future carbon offsetting scheme for individual consumers would have to carefully consider the following with respect to commercial aviation:

- Accounting for emissions that are already addressed through the EU ETS and/or CORSIA [see sections 3.2 and 3.3, respectively];
- Providing offsetting options for non-online ticket sales; and
- Ensuring the effective provision of carbon offsetting schemes on international routes.[102]

Greenhouse gas removals

The aviation industry is likely to rely heavily on GGRs to achieve ambitious climate goals, if demand is not constrained.[103] Greenhouse gas removal mechanisms (GGRs) remove GHGs from the atmosphere and store them, either geologically (i.e. in rocks underground), or in trees and soils. To find out more about the technical options for GGRs see POSTnote 549: Greenhouse Gas Removal.

The CCC has suggested that while GGRs will play a role in offsetting emissions from the aviation industry, there must be genuine emissions reductions. [104] The CCC has also advised appropriate GGR offsets should be used, rather than traditional offsets, to reach net-zero emissions. These will mostly be based on carbon capture and storage (CCS), which will likely be costlier than traditional offsets such as afforestation.[105]

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99 e.g. Offsetting carbon emissions: 'It has proved a minefield', The Guardian [online], 2 August 2019 (accessed on 16 March 2020) and Revealed: The carbon offsetting 'Wild West', The Telegraph [online], 21 February 2020 (accessed on 16 March 2020)

100 Carbon offsetting in transport: a call for evidence., *gov.uk*, 18 July 2019

101 HM Government, *Carbon offsetting in transport: A call for evidence*, July 2019, p10

102 HM Government, *Carbon offsetting in transport: A call for evidence*, July 2019, p10

103 Greenhouse Gas Removal Summary, The Royal Society and Royal Academy of Engineering, February 2018

104 Net-zero and the approach to international aviation and shipping emissions: Letter from Lord Deben to Grant Shapps, Committee on Climate Change, 24 September 2019

105 Net-zero and the approach to international aviation and shipping emissions: Letter from Lord Deben to Grant Shapps, Committee on Climate Change, 24 September 2019

In the March 2020 Budget, the Chancellor, Rishi Sunak, announced £800 million of funding for the development of CCS sites in the UK.[106] For more information on the history of CCS policy, as well as recent developments, see Commons Library Briefing: Carbon capture usage and storage.

3.2 Emissions trading schemes

EU ETS

The European Union (EU) was the first international body to develop and implement a market-based approach to mitigate CO_2 emissions associated with aviation activity in 2012.[107] This was done through the EU's Emissions Trading System (EU ETS). The EU ETS has also established a carbon pricing mechanism and the world's largest carbon market. The UK has a carbon price floor to support the EU ETS price.[108]

The EU ETS sets an EU-wide cap on the total amount of greenhouse gas emissions from energy intensive sectors including power stations and industrial plants. The cap decreases over time (1.74% each year) to reduce overall emissions.[109] Airlines operating between the 31 countries are covered within the EU ETS but via a separate cap. Approximately 140 UK-administered aircraft operators take part in the EU ETS.[110]

Under the EU ETS all airlines operating within EEA are required to monitor, report and verify their emissions. Emissions from flights to or from the EEA with an origin or destination outside the EEA are not currently included in the EU ETS. However, the original plan was for these emissions to be included in the scheme. Plans were put on hold to support the development of CORSIA (see section 3.3, below). If the European Commission decide not to incorporate CORSIA into EU law, they say they intend to revert the EU ETS back to its full scope from 2024.[111]

UK ETS

A UK Emissions Trading Scheme (UK ETS) replaced the UK's participation in the EU ETS on 1 January 2021. The legislative basis for this scheme is the *Greenhouse Gas Emissions Trading Scheme Order 2020*.

The UK ETS covers UK domestic flights, flights between the UK and Gibraltar, and flights from the UK to the EEA. Any aircraft operator that meets the thresholds for inclusion will be obliged to report and

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106 HM Treasury, *Budget 2020*, HC121, 12 March 2020, para 1.241

107 International Civil Aviation Organization's Carbon Offset and Reduction Scheme for International Aviation (CORSIA), The International Council on Clean Transportation, 13 February 2017

108 More information on the Carbon Price Floor can be found in: Brexit: Energy and Climate Change, Commons Library Briefing Paper CBP-8394, 19 June 2019, p43

109 European Commission, Climate Action, 'Emissions cap and allowances' (accessed on 27 March 2020)

110 Meeting climate change requirements if there's no Brexit deal, *gov.uk*, 12 October 2018

111 Reducing emissions from aviation, European Commission. (accessed on 18 February 2020)

surrender allowances for emissions from included flights on these routes.

The Government published guidance for aviation operators on complying with the UK ETS in December 2020.

In 2018, activities based in the UK accounted for 8% of the EU ETS emissions.[112] The UK-EU Trade and Cooperation Agreement (TCA) provides for UK and EU cooperation on carbon pricing, including through linking respective carbon pricing systems. In a letter to the Chair of the EU Scrutiny Committee on 3 Feb 2021, BEIS Minister Lord Callanan wrote:

> …the UK recognises the importance of international co-operation on carbon pricing, and with there being more than 20 emissions trading systems globally, we remain open to linking the UK ETS internationally in principle.[113]

3.3 CORSIA

At a 2016 meeting of ICAO, the UN aviation agency, 192 countries agreed a Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA), though participation is not currently compulsory.[114]

CORSIA is a global market-based 'baseline-and-credit' mechanism designed to offset international aviation CO_2 emissions. CORSIA's aim is to achieve ICAO's medium-term goal of Carbon Neutral Growth from 2020 (CNG2020) – it does not provide a route to reducing emissions overall.

Participating airlines will have to offset any growth in their emissions above a 2019 baseline (see box COVID-19 adjustments to CORSIA) from 2021 onwards. Air service operators will offset CO_2 through acquisition and cancellation of emissions units from the global carbon market. The CORSIA implementation plan sets out the following steps:

1 CORSIA requires that all participant countries monitor their baseline emissions through 2019-2020.

2 There is then a voluntary pilot period from 2021-23 and a still-voluntary first phase from 2024-26.

3 Then a second compulsory phase begins in 2027. ICAO members participating in CORSIA will need to ensure that aeroplane operators comply with CORSIA offsetting requirements every three years.

4 After 2035, the ICAO aims to replace offsetting with direct emissions reductions, but offsetting measures may still be needed.

An airline can reduce its carbon offsetting requirements by using CORSIA eligible fuel (CEF), and any remaining CO_2 offsetting requirements for the compliance period must be purchased as emission

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112 EU Emissions Trading System (ETS) data viewer, EEA (accessed on 26 February 2020)
113 Letter Lord Callanan to Sir William Cash Chair of EU Scrutiny Committee, 3 Feb 2021
114 Explainer: How aviation could, finally, agree a climate deal, Carbon Brief, 26 September 2016 (accessed on 18 February 2020)

units through carbon markets and recorded within a central CORSIA registry.[115]

The CCC recently encouraged the UK Government to go further and to push at the next ICAO meeting for future international measures that incentivise GGRs for all emissions from aviation, not just emissions above a 2019-2020 baseline.[116]

COVID-19 adjustments to CORSIA baseline

In light of COVID-19, the ICAO Council agreed to implement a safeguard adjustment to the 2021-2023 pilot phase of CORSIA. The emissions baseline above which international airlines must offset their emissions will now be calculated using only 2019 emissions, rather than averaging 2019 and 2020 emissions. The dramatic reduction in 2020 aviation operations, caused by the COVID-19 pandemic and associated travel bans, would otherwise have caused a significant reduction in the CORSIA baseline, calculated as the average of the sector's 2019 and 2020 emissions.

The International Council on Clean Transportation (ICCT) estimated that this change will allow airlines to emit 81 million metric tonnes, or 30% more carbon emissions, during the pilot phase of CORSIA.

Airline industry groups have applauded the decision. Airline association IATA welcomed the decision, describing it as "a pragmatic way forward".[117]

Adjustments to the rules will be re-examined for subsequent CORSIA phases at the first periodic review in 2022.

From 1 January 2021, 88 States, representing over 75% of international aviation activity, will voluntarily participate in CORSIA.[118] The UK Government has opted in to participate in the voluntary pilot phase of the scheme starting in 2021.

From 18 Jan to 28 Feb 2021, the DfT is consulting on proposals for implementing CORSIA. As part of this consultation it is seeking views on "high-level options for implementing CORSIA alongside a UK ETS". A second consultation in 2021 is expected to follow with "detailed policy design" setting out any interaction between the two schemes.[119]

Views on CORSIA

CORSIA was the first global carbon pricing instrument to cover an entire sector and was hailed as a 'major political achievement'.[120] It is anticipated that CORSIA will mitigate (i.e. offset) around 2.5 billion tonnes of CO_2 between 2021 and 2035, an annual average of 164 million tonnes of CO_2.[121]

115 CORSIA At a glance: CORSIA eligible fuels (accessed on 29 January 2020)
116 Net-zero and the approach to international aviation and shipping emissions: Letter from Lord Deben to Grant Shapps, Committee on Climate Change, 24 September 2019
117 Ian Taylor, ICAO slammed for changing baseline for airline offset scheme, 3 July 202
118 CORSIA States for Chapter 3 State Pairs, ICAO, July 2020 (accessed on 3 September 2020)
119 DfT, Implementing the Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA), 18 Jan 2021
120 Fact Sheet: CORSIA and carbon pricing, IATA
121 CORSIA explained, Aviation Benefits Beyond Borders (accessed on 23 March 2020)

However, the scheme receives ongoing criticism from a number of commentators and advisory bodies such as the Committee on Climate Change, and environmental campaign groups such as the AEF and Transport and Environment, detailed further below.

Participation in CORSIA

From 1 January 2021 88 States, representing over 75% of international aviation activity, will voluntarily participate in CORSIA.[122]

There are some notable non-participants:

- China, the second biggest global source of passenger aviation emissions[123], is not currently participating, despite being an early supporter of CORSIA.[124]
- Russia and India have also not yet volunteered for the scheme.[125]

The International Air Transport Association (IATA) forecasts suggest that China will be the world's largest aviation market as early as 2022, and India will be the third largest by 2025.[126] Russia and China have criticised CORSIA arguing the increase in costs caused by the scheme would unfairly penalize emerging and developing countries.[127] The US is still participating in ICAO measures, including CORSIA.[128]

The International Council on Clean Transportation (ICCT) has suggested that due to the coverage gap resulting from CORSIA exemptions, they do not expect CORSIA to achieve carbon neutral growth from 2020, regardless of low-carbon fuel use or operational and design improvements.[129]

Unambitious and uncertain outcomes

In their 2019 Net Zero report, the CCC said that the effectiveness of CORSIA was dependent on some uncertain factors. The CCC highlighted uncertainties around the **availability and cost of robust carbon units in the longer term** and broader developments in international carbon units markets. The CCC also said CORSIA's goal of carbon neutral growth from 2020 was not ambitious enough. However, they also said that CORSIA could provide a framework for future goals to build upon:

> Despite the challenges, **CORSIA offers a route to limit post-2020 aviation emissions**. It can provide an interim measure allowing new solutions to become available and support the

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122 CORSIA States for Chapter 3 State Pairs, ICAO, July 2020 (accessed on 3 September 2020)
123 'Worse Than Anyone Expected': Air Travel Emissions Vastly Outpace Predictions, The New York Times [online], 19 September 2019 (accessed on 18 February 2020)
124 China no longer participating in start of aviation emissions deal, Reuters, 4 July 2018
125 CORSIA States for Chapter 3 State Pairs, ICAO, July 2020 (accessed on 3 September 2020)
126 International Air Transport Association, 20-Year Air Passenger Forecast, 2018
127 China denounces U.N. aviation emissions plan in blow to industry efforts, Reuters, 25 September 2019
128 CORSIA States for Chapter 3 State Pairs, ICAO, July 2020 (accessed on 3 September 2020)
129 International Civil Aviation Organization's Carbon Offset and Reduction Scheme for International Aviation (CORSIA), The International Council on Clean Transportation, 13 February 2017

> development of a global market in carbon units, particularly for GHG removal technologies.[130]

In their 2018 report on the Airports National Policy Statement, the House of Commons Transport Select Committee raised concerns that the impacts of aviation on climate change were being misrepresented and that Government plans to rely on carbon offsetting schemes were 'ill-advised'.[131]

AEF (Aviation Environment Federation) raised its concerns over international market-based mechanisms in evidence to the Committee:

> While there is a high-level agreement to implement CORSIA, much of the detail that will determine its environmental integrity is still being debated and cannot be taken as offering a guarantee of effective carbon mitigation, while the EU ETS for aviation has been scaled back to cover only intra-EU flights for the foreseeable future.[132]

Lack of public scrutiny

Further, the ICAO have been accused of operating in a way that does not provide enough opportunity for public scrutiny.[133] The NGO Transport and Environment have suggested this makes it easier for the industry to exert its influence on decision-making.[134] There are also concerns that the CORSIA will be used to block taxation on aviation or further measures to reduce carbon emissions from the industry.[135]

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130 Net Zero – The UK's contribution to stopping global warming, Committee on Climate Change, May 2019, p116

131 Transport Committee, *Airports National Policy Statement*, 23 March 2018, HC 548-III 2017-19, p151&153

132 Written evidence submitted by the Aviation Environment Federation (NPS0031)

133 The UN is failing on all fronts to tackle the climate impact of flying, EURACTIV, 6 June 2018 (accessed on 18 February 2020)

134 Why ICAO and Corsia cannot deliver on climate, Transport and Environment, 22 September 2019

135 EU countries urged to reject UN scheme that could thwart action on aviation emissions, EURACTIV, 23 September 2019 (accessed on 18 February 2020)

4. Technology and operations

Changes to aviation operations on the ground and in the sky can improve aircraft and engine efficiency. Sustainable aviation fuels and novel electric and hybrid-electric flight all provide potential opportunities to reduce aviation emissions, though their potential for net emissions reductions, and when they are likely to be commercially available remain subjects of debate.

The UK aviation industry estimates that technological improvements that increase fuel efficiency (fleet upgrades, including electric flight, and improved operations) could mitigate 37% of projected total UK aviation emissions in the year 2050.[136] An overview of technical developments to help decarbonise the aviation industry can be found in *POSTnote: Climate Change and Aviation*.

R&D in the UK's aerospace industry – the second largest in Europe, and third largest globally – could deliver some of these technical innovations. The Government supports the aerospace industry through several initiatives:

- The **Aerospace Growth Partnership** (AGP), described as 'a strategic partnership between the UK Government, industry and other key stakeholders, established to secure the future of the UK aerospace industry in the face of an ever changing, and increasingly competitive global landscape. This partnership is intended as a vehicle to tackle barriers to growth, boost competitiveness and exports and grow the number of high value jobs in the UK.' The AGP has four working groups (UK Aerospace Strategy, Manufacturing & Supply Chain Competitiveness, Sector Skills, and Engagement and Communications) each made up of Industry and Government representatives.[137]
- The **Aerospace Technology Institute** (ATI), which promotes and funds 'transformative technology in air transport'. The ATI programme represents £3.9 billion of joint funding between industry and government. Projects funded include, more efficient engines (such as the Rolls Royce UltraFan), composite materials (which can reduce the weight of aircraft and therefore increase fuel efficiency) and novel hybrid-electric aircraft (such as the Airbus, Rolls Royce and Siemens hybrid electric aircraft, E-Fan X). Further details of projects funded by the ATI can be found on the ATI project portal.

In *Aviation 2050* (see section 2.1, above), the Government outlined a series of potential technology and operations policy measures for industry to consider and adopt over the next 10 to 15 years:[138]

- **Sustainable aviation fuels** (section 4.1);
- **Operational and Air Traffic Management** (section 4.2);

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136 Decarbonisation Road-Map, Sustainable Aviation, 4 February 2020, p21
137 Working Groups, Aerospace Growth Partnership (accessed on 19 March 2020)
138 HM Government, *Aviation 2050 The future of UK aviation: A consultation*, **Cm 9714**, Dec 2018

- New technology – **engines and airframes** (sections 4.3 and 4.4).

These are discussed further in the rest of this section.

4.1 Sustainable aviation fuels

Alternatives to fossil fuel-derived kerosene are referred to by a number of different names. Here we will use **sustainable aviation fuels** (SAF) as this is the term used most commonly by both the aviation and aerospace industries, and the UK Government. Further technical information on sustainable aviation fuels and their advantages and disadvantages can be found in *POSTnote 616: Low Carbon Aviation Fuels* (2020).

Separately to SAF, some hydrogen-powered aircraft are also being developed, and an independent study on the technological and economic aspects of hydrogen-powered aviation, its feasibility and impact on the climate was published in May 2020.

Alternatives to fossil fuel-derived kerosene are sometimes referred to as **low-carbon fuels**. These are defined as 'fuels that provide high greenhouse gas lifecycle savings (>60%) when compared with their fossil equivalents'.[139] Not all proposed sustainable aviation fuels qualify as low carbon fuels, for example CORSIA-eligible fuels need only reduce the carbon emissions by 10% compared to fossil fuel-derived kerosene.[140]

SAF are chemically identical to fossil fuel-derived kerosene but are produced from different raw materials and processes.[141] Sustainable aviation fuels (SAF) include:

- **Biofuels**: fuels from recycled waste (both biological e.g. food and garden waste, and non-biological, e.g. plastics) and
- **synthetic fuels** (also called electrochemical fuels, i.e. fuels that are produced through reactions between CO_2 and water).

SAF provide a 'drop-in' solution within conventional aircraft (i.e. they can be used with little/no change to engine technology or airport infrastructure) and can reduce the net carbon emissions of a fuel over its lifetime by up to 70%.[142]

As of September 2020, around 270,000 flights have been made using 'Sustainable Aviation Fuel'.[143] Existing safety standards require low-carbon aviation fuels to be blended with at least 50% jet fuel.[144] Estimates suggest that they could mitigate between 5% and 30% of carbon dioxide (CO_2) emissions from UK aviation by 2050.[145]

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139 Sustainable Fuels UK Road-Map, Sustainable Aviation, 2018
140 CORSIA Sustainability Criteria for CORSIA Eligible Fuels, ICAO, June 2019
141 National Academies of Science, Engineering and Medicine , *Sustainable Alternative Jet Fuels. In: Commercial Aircraft Propulsion and Energy Systems Research: Reducing Global Carbon Emissions*, 2016
142 Decarbonisation Road-Map, Sustainable Aviation, 4 February 2020, p35
143 Sustainable aviation fuel, Aviation Benefits Beyond Borders (accessed on 15 September 2020)
144 Sustainable Aviation Fuels, EASA, (accessed on 19 March 2020)
145 Low-carbon aviation fuels, POSTnote 616, 24 February 2020

The Committee on Climate Change (CCC) net zero scenario (their recommendations to the UK Government on how to achieve net zero by 2050) includes a 10% uptake of 'sustainable biofuels' for aviation by 2050. It does not project higher uptake due to the range of competing potential uses for biofuels across other sectors – and attendant pressures on supply. There is uncertainty over which use will be most cost-effective and thus likely to take the lion's share of the limited supply. The CCC further advises that novel (or synthetic) fuels, e.g. electrochemical fuels formed from CO_2 and water, "could allow greater [GHG] reductions, but their development is speculative and should not be relied upon".[146]

Government policy on sustainable aviation fuels

The Government has proposed to do the following on sustainable aviation fuels:

- continue to work closely with industry to maximise the opportunities for the development of sustainable aviation fuels
- assess options to further promote sustainable aviation fuels. This includes continuing to monitor progress towards the development fuel sub-target in the RTFO [Renewable Transport Fuel Obligation] as part of the wider carbon budget process
- analyse the potential of low carbon fossil fuels from wastes to help decarbonise transport, including aviation
- work in ICAO towards a global target and market for sustainable aviation fuels, accompanied by robust sustainability criteria covering environmental, social and economic issues[147]

It currently supports the development of sustainable aviation fuel through its inclusion in the Renewable Transport Fuel Obligation (RTFO) and through the Future Fuels for Flight and Freight (F4C) competition.

Aviation fuels and the Renewable Transport Fuel Obligation (RTFO)

Introduced in 2008, the RTFO is a market-trading mechanism, described by the Government as the "UK's main mechanism for supporting the supply of renewable fuels in transport." In 2018 the Government announced that the RTFO would be extended to include sustainable aviation fuels.[148]

Under the RTFO, suppliers of more than 450,000 litres per year of fuel intended for road transport, non-road mobile machinery (e.g. construction, farming, gardening, rail cars and vehicles operating on

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146 Net-zero and the approach to international aviation and shipping emissions: Letter from Lord Deben to Grant Shapps, Committee on Climate Change, 24 September 2019

147 HM Government, *Aviation 2050 The future of UK aviation: A consultation*, **Cm 9714**, Dec 2018, p192

148 New regulations to double the use of sustainable renewable fuels by 2020, *gov.uk*, 13 April 2018 (accessed on 20 March 2020)

waterways) and aviation must ensure a percentage (9.75% in 2020, at least 12.4% by 2032[149]) of the fuel produced is renewable.[150]

Fuel producers are rewarded financially for the renewable fuel they supply - each litre of fuel is awarded one or more Renewable Transport Fuel Certificates (RTFC) worth 80p (in 2018). Some fuels are eligible to more than one RTFC per litre, further incentivising their production. For example, when a fuel is awarded 2 RTFCs per litre (a 'multiplier' of 2) they would receive £1.60 per litre of renewable fuel produced.[151]

Some campaigners have cautioned the Government about the risk that extending the RTFO to aviation could reduce the cost of aviation fuel.[152] In their 2018 consultation on the RTFO, the Government responded to these concerns, stating that they "do not anticipate the measure will subsidise fossil aviation fuel".[153]

In 2020, Sustainable Aviation, a UK aviation industry consortium, called on the Government to apply a multiplier of 1:2 to sustainable aviation fuels within the RTFO, i.e. each litre of renewable aviation fuel produced would be eligible for two RTFCs (see above).[154] This would be in line with EU incentives for sustainable aviation fuels, as outlined in the Renewable Energy Directive, the overall EU target for Renewable Energy Sources consumption.[155]

However, some in the industry think that a multiplier of 1.2 is inadequate and that a multiplier of between 2.5 and 5 is needed to bridge the gap between fuel prices.[156]

Future Fuels for Flight and Freight competition (F4C)

The F4C is a funding competition launched by the government on the 27 April 2017 by the Department for Transport (DfT) to "increase domestic production of advanced low carbon fuels capable of tackling emissions from the hard-to-decarbonise aviation and HGV sectors in pursuit of long-term UK decarbonisation targets".[157]

F4C will provide a total of £22 million of developmental and capital funding to 2021. To date, two aviation fuel projects have been shortlisted: Altalto (Velocys Waste to Jet Fuel Project, site in Immingham, Lincolnshire, planned to open in mid 2020s) and LanzaJet

149 New regulations to double the use of sustainable renewable fuels by 2020, *gov.uk*, 13 April 2018 (accessed on 20 March 2020)
150 Department for Transport, *The Renewable Transport Fuel Obligations Order: Government response to the consultation on amendments*, **Cm 9494**, Sept 2017, p21
151 Department for Transport, *The Renewable Transport Fuel Obligations Order: Government response to the consultation on amendments*, **Cm 9494**, Sept 2017, p10
152 RTFO response – aviation fuels, AEF
153 Department for Transport, *The Renewable Transport Fuel Obligations Order: Government response to the consultation on amendments*, **Cm 9494**, Sept 2017, p66&70
154 Sustainable Aviation CO2 Roadmap, Sustainable Aviation, 2016
155 Renewable Energy – Recast to 2030 (RED II), European Commission (accessed on 19 March 2020)
156 Airbus exec.: EU 'bonus' for aviation biofuels may be too little, EURACTIV, 16 October 2017 (accessed on 27 February 2020)
157 Future Fuels for Flight and Freight Competition (F4C), Ricardo Energy and Environment (accessed on 19 March 2020)

(Sustainable Aviation Fuel From Waste-Based Ethanol), but as yet there has been no announcement as to the scale of funding that might be provided for each project .[158]

4.2 Operational changes

There is potential to reduce aircraft fuel consumption and therefore emissions by improving the efficiency of airspace use and air traffic management. The UK aviation industry has suggested that improved operations could mitigate as much as 4% of projected 2050 aviation emissions.[159]

Airspace modernisation

The easiest way to think of airspace is as a motorway network in the sky. Airspace is the volume of space above ground level and extends as far as aircraft can fly. The current legal and policy framework for airspace is set by Government, in accordance with international and European standards and requirements.

In 2017 the Government published its *Strategic Case for Airspace Modernisation*, setting out the benefits of airspace modernisation.[160] It argued that new technologies such as Performance Based Navigation could improve the efficiency of UK airspace and that this in turn could lead to emissions reductions by reducing unnecessary fuel burn.[161] The Government has said that it will draft or revise airline and airport Codes of Practice and Standard Operating Procedures to "increase uptake of measures such as … continuous ascent and descent, reduced stacking and holding and advising airports to install infrastructure to support these".[162]

Some reforms to airspace and air traffic management and procedures are contained in the *Air Traffic Management and Unmanned Aircraft Bill [HL] 2019-21*. This Bill had its Third Reading in the Lords on 28 January 2021, and Second Reading in the Commons on 2 February 2021.

However, while airspace modernisation may decrease the emissions of each individual plane, part of the Government's rationale is to use it to increase overall capacity.[163] Climate policy researcher, Professor Alice Larkin, has argued that this would mean more aircraft entering UK airports and an attendant increase in emissions – a so-called 'rebound effect'.[164]

To find out more about the UK's changing airspace, see Commons Library briefing: *Airspace change and modernisation* (2018).

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158 Future Fuels for Flight and Freight Competition, Ricardo Energy and Environment (accessed on 28 February 2020)
159 Decarbonisation Road-Map, Sustainable Aviation, 4 February 2020, p5
160 HM Government, *Upgrading UK airspace: strategic rationale*, February 2017
161 HM Government, *Upgrading UK airspace: strategic rationale*, February 2017
162 HM Government, *Aviation 2050 The future of UK aviation: A consultation*, **Cm 9714**, Dec 2018, p191-2
163 HM Government, *Aviation 2050 The future of UK aviation: A consultation*, **Cm 9714**, Dec 2018, para 3.4
164 All adrift: aviation, shipping, and climate change policy, Climate Policy, Alice Bows-Larkin, 6 December 2014

Changes to ground operations at airports

Improvements in efficiency and electrification of ground support equipment at airports can produce some emissions savings.

For example, on 21 February 2020 London Heathrow airport announced that it has 'gone carbon neutral' and is 'working towards operating a zero carbon infrastructure by mid 2030s'.[165] However, commentators, climate activists and members of the general public criticised the announcement as the 'carbon neutral' claim only covers the parts of the airport that Heathrow runs itself and does not cover emissions from flights, the major source of emissions from the aviation industry.[166]

In *Aviation 2050* (see section 2.1, above), the Government said that it would draft or revise airline and airport Codes of Practice and Standard Operating Procedures to increase uptake of measures such as e-taxiing, reduced taxi times, Fixed Electrical Ground Power, Pre-Conditioned Air and electric airside vehicles. It indicated that it would advise airports to install infrastructure to support these measures.[167] At the same time, it proposed the following, additional, policy measures:

- Advising airports and airlines to **report on compliance with the emissions reduction measures** in airport and airline Codes of Practice and Standard Operating Procedures
- Advising airports to **publish league tables on environmental efficiency** of airport and airline operations
- Encouraging all major UK airports to gain ACI (Airports Council International) **carbon neutral airport accreditation**
- **Introducing emissions criteria within landing based charging schemes** at the UK's major airports
- **Working in ICAO to produce guidance for improving and measuring the efficiency of operations** including considering publishing worldwide fuel efficiency performance or setting targets.[168]

4.3 Conventional aircraft development

Jet fuel represents a significant proportion of operating costs for air service operators. The International Air Transport Association (IATA) estimates that in 2020, without the coronavirus pandemic, the global aviation sector would have spent around US$182 billion on jet fuel, representing 22% of operating expenses.[169]

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165 Heathrow set target for zero carbon, Heathrow, 21 February 2020 (accessed on 17 March 2020)
166 Heathrow's carbon footprint announcement was just plane crazy – our 7 favourite comments, The Poke [online], 21 February 2020 (accessed on 19 March 2020)
167 HM Government, *Aviation 2050 The future of UK aviation: A consultation*, **Cm 9714**, Dec 2018, p191-2
168 HM Government, *Aviation 2050 The future of UK aviation: A consultation*, **Cm 9714**, Dec 2018, p191-2
169 Fuel Fact Sheet, IATA (accessed on 25 February 2020)

The aviation and aerospace industries have argued that, due to high fuel costs, there has long been motivation for them to increase fuel efficiency of their aircraft. The CCC's scenarios reflect a 1.4% annual improvement in fuel efficiency, in line with the historical average since 2000 for UK departing flights on a seat-per-km basis.[170] This is lower than ICAO's 'aspirational goal' of 2% fuel efficiency improvement per year.[171]

There are several means by which fuel efficiency improvements can be achieved:

- **More efficient engines**, including both advanced and conventional jet designs as well as the introduction of some commercial hybrid-electric aircraft in the 2040s (see section 4.4, below);
- **Improvements in aircraft design**, including use of design elements such as high aspect ratio wings and composite materials; and
- **Efficiency improvements** in airlines' operations and in airspace management (see section 4.2, above).

The UK Government said that it will:

- investigate how the Government's Industrial Strategy aerospace funding can provide greater support for progression of the UK's environmental objectives through new aerospace technologies
- negotiate in ICAO for a strengthened CO_2 standard[172]

It has also said that it will continue to support the aerospace industry's efforts to increase fuel efficiency and reduce emissions to the tune of about £3.9 billion of R&D funding, alongside industry, to 2026.[173]

4.4 Electric and hybrid-electric flight

Fully electric flight presents a considerable technological challenge, primarily because flight requires extremely high levels of power and currently available batteries are too heavy. Significant advances in battery technology are required to achieve full electrification, particularly for large aircraft and flights longer than 300–500 km (190–310 miles).[174]

In CCC projections, hybrid-electric planes will make up less than 10% of km flown in 2050 and there are "no full-electric aircraft in the [CCC net

170 Net-zero and the approach to international aviation and shipping emissions: Letter from Lord Deben to Grant Shapps, Committee on Climate Change, 24 September 2019
171 CORSIA Implementation plan (accessed on 18 February 2020)
172 HM Government, *Aviation 2050 The future of UK aviation: A consultation*, Cm 9714, Dec 2018, p192
173 New aerospace technologies to get £365 million funding, *gov.uk*, 12 July 2016 (accessed on 20 February 2020)
174 Climate change and aviation, POSTnote 615, 11 February 2020

zero by 2050] scenario which, particularly for long haul flights, are unlikely to be feasible by 2050." [175]

Aviation industry estimates of technological progress suggest that:

- small (150–200-seat) hybrid electric aircraft will become available on short-haul routes around 2040 and fully electric after 2050.
- smaller fully electric aircraft (20–130 seats) may be used by 2040 on domestic routes, particularly in remote or island areas.
- There is potential for very small fully electric aircraft to be used for intra-urban transport by 2025 ('air taxis'). [176]

There are a number of companies worldwide that are developing electric and hybrid-electric planes, icnludign:

- The E-Fan X hybrid electric aircraft was due to fly for the first time in 2021. However, in April 2020, Airbus and Rolls Royce announced they were ending the project early to "refocus their efforts". The impact of the coronavirus pandemic was not mentioned.
- Island-hopping in the Orkneys: Project Fresson: Cranfield Aerospace Solutions Limited, in collaboration with Denis Ferranti Meters Limited and Rolls-Royce plc, are converting a Britten-Norman Islander 9-seat aircraft to all-electric propulsion. [177] The project received a £9 million UK Government grant in 2019 through the Aerospace Technology Institute (see section 4). [178] The electric aircraft will be operated by Logan Air and will be the UK's first passenger-carrying aircraft capable of all-electric flight. The funding period ends in March 2022, with the first flight of the aircraft planned for April 2022. [179]

UK Government support for development of electric and hybrid-electric aircraft

In July 2018 the government announced £343 million of joint government-industry funding "to support a new era of cleaner, greener flight". [180] Supported by UKRI (United Kingdom Research and Innovation, the coordinating body for research in the UK) and ATI (Aerospace Technology Institute, see section 4, above), £255 million of this is funding 18 new research and technology projects. The projects will help develop technologically advanced aircraft, create more efficient

175 Net-zero and the approach to international aviation and shipping emissions: Letter from Lord Deben to Grant Shapps, Committee on Climate Change, 24 September 2019
176 Climate change and aviation, POSTnote 615, 11 February 2020
177 Project Fresson: 9-seat aircraft electric propulsion conversion (Britten Norman), UKRI, (accessed on 20 March 2020)
178 Cranfield Aerospace Solutions (CAeS) announces £9m UK Government grant for the development of electric flight, Cranfield University Press Release, 18 November 2019
179 Project Fresson: 9-seat aircraft electric propulsion conversion (Britten Norman), UKRI, (accessed on 20 March 2020)
180 Lift off for electric planes - new funding for green revolution in UK civil aerospace, *gov.uk,* 16 July 2018 (accessed on 11 March 2020)

engines, and manufacture cleaner, quieter aircraft to help reduce emissions.[181]

In December 2018, the Government published the Aerospace Sector Deal to 'build on our successes by positioning the UK to take advantage of the global move towards hybrid-electric and electric propulsion and to exploit related new markets – drones and Urban Air Mobility vehicles.'[182]

The Government is also supporting the aviation industry to decarbonise through initiatives such as the Future Flight Challenge and the Faraday Battery Challenge, both of which are part of the Industrial Strategy Challenge Fund:

- The **Future Flight Challenge** was set up in 2019 to support the development of novel aircraft, e.g. freight-carrying drones, urban air vehicles and hybrid regional aircraft, and help to develop supporting ground infrastructure and the regulation and control systems that will be required to facilitate future use of novel aircraft.[183] It is supported by joint investment from the Government (£125 million) and industry (up to £175 million). The challenge will provide for 4 years of funding to successful applicants, ending in 2022.[184]
- The **Faraday Battery Challenge** (FBC) was set up in 2018 to develop batteries that are cost-effective, high-quality, durable, safe, low-weight and recyclable. The Government has pledged to invest up to £246 million in the FBC.[185] No projects within the FBC are developing battery technology specifically for aviation, however, the research and development funded by the challenge could contribute to battery technology breakthroughs required to support commercial electric flight.[186]

Jet Zero Council

On 12 June 2020, the Transport Secretary announced plans to convene the "Jet Zero Council".[187] The Government has described this initiative as:

> …a partnership between industry and government to bring together ministers and chief executive officer-level stakeholders to drive the ambitious delivery of new technologies and innovative ways to cut aviation emissions.[188]

The council is jointly chaired by the Business Secretary and Transport Secretary and will "focus on developing UK capabilities to deliver net zero-emission commercial flight by":

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181 HM Government, *Aviation 2050 The future of UK aviation: A consultation*, Cm 9714, Dec 2018, para 8.16
182 HM Government, *Industrial Strategy: Aerospace Sector Deal*, Dec 2018
183 Future Flight, UKRI (accessed on 3 March 2020)
184 Future flight challenge, Innovation Funding Service, *gov.uk* (accessed on 19 March 2020)
185 Faraday Battery Challenge, UKRI (accessed on 25 February 2020)
186 Climate change and aviation, POSTnote 615, 11 February 2020
187 DfT, Transport Secretary's statement on coronavirus (COVID-19): 12 June 2020, 12 June 2020
188 Jet Zero Council, [accessed: 7 October 2020]

- developing and industrialising zero-emission aviation and aerospace technologies
- establishing UK production facilities for sustainable aviation fuels (SAF) and commercialising the industry by driving down production costs
- developing a coordinated approach to the policy and regulatory framework needed to deliver net zero aviation by 2050

In January 2021, the Transport Secretary said the Council had "met on one occasion but has sub-committees that have met on many occasions, because they are the work horses of the Jet Zero Council and they bring together academia, the sector itself, Government and international partners to deliver zero-carbon flight by 2020." [189]

[189] HC Deb 1 Feb 2021 c6MC

5. Demand management and taxation

In September 2019 the Chair of the CCC, Lord Deben, highlighted to the Secretary of State for Transport, Grant Shapps, the opportunity for further emissions savings from additional demand constraint, i.e. limiting passenger growth to less than 25% above current levels by 2050. The CCC argued that this could be driven by future changes in consumer preferences and social norms, or by more ambitious policy.[190]

In a report on behavioural change and aviation for the CCC, Dr Richard Carmichael of Imperial College London argued that it is vital to constrain rising demand, despite the political challenges of this:

> Sensitivity about pricing annual holidaymakers out of the sky has discouraged greater taxation on flights and policy has not addressed rising aviation demand. However, well-designed fiscal measures could offer effective, fair and publicly acceptable means to confront the risk of unrestrained growth in demand in the absence of alternative low-carbon aviation technologies. Fairness and how impacts are distributed are of key importance to public acceptability of policy in general…and will be especially important for aviation.[191]

However, the aviation industry and its supporters say that there are compelling economic arguments in favour of continued growth (see section 1.3).

The Government has said that it will consider the use of all feasible emissions reduction options, including demand management and behavioural change.[192] However, no specific demand management measures have been proposed, and no further mention of such measures has been made in either the Government's response to CCC recommendations, or reports relating to the Transport Decarbonisation Plan.

5.1 Individual consumer choices

There is evidence that more people worldwide are considering at least reducing their air travel.[193] A survey published in 2020 by the European Investment Bank found that:

- 75% of Europeans said they would fly less in 2020 for environmental purposes.
- 36% of Europeans said they already fly less for this reason.

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190 Net-zero and the approach to international aviation and shipping emissions: Letter from Lord Deben to Grant Shapps, Committee on Climate Change, 24 September 2019

191 Behaviour change, public engagement and Net Zero, Imperial College London, 10 October 2019

192 HM Government, *Aviation 2050 The future of UK aviation: A consultation*, **Cm 9714**, Dec 2018, para 3.96

193 2nd EIB climate survey, 14 January 2020 (accessed on 7 February 2020)

- For China and the USA, 94% and 69% said they intended to fly less in 2020, respectively.[194]

In the UK, before the pandemic air passenger numbers were growing overall.

5.2 Taxation

In the UK aviation is taxed primarily through air passenger duty (APD). There is no VAT payable on air tickets and no aviation fuel duty, furthermore, as indicated in section 3 above, as yet there is only limited price signalling through emissions trading.

Many commentators have questioned the fairness of how aviation is taxed, particularly compared to road transport. Dr Richard Carmichael (Imperial College London) said in a report for the CCC:

> Given the scope for frequent flyers to have carbon footprints many times that of the average UK household, a lack of policy in this area is likely to be increasingly seen as inconsistent and unjust and risks damaging public engagement with climate action.[195]

However, the industry has called on Government to reduce taxation on aviation, claiming that it has a 'damaging impact' on the aviation industry and acts as a barrier to economic growth (see Air Passenger Duty, below).

Given these contrasting views, reform of aviation taxes is subject to ongoing debate and there are several proposals for policy change. Three of the most often cited – reforming APD, taxing aviation fuel and introducing a 'frequent flyer levy' – are discussed below.

Air Passenger Duty

Air Passenger Duty (APD) was introduced in the UK from 1 November 1994 and is charged on all passenger flights from UK airports. The rate of duty varies according to passenger destination and the class of passenger travel.[196]

In the UK airlines have been campaigning for years to reduce APD. The industry's 'fair tax on flying' campaign is publicly supported by 44 MPs and peers. The aim of the campaign is to bring APD in line with other countries and to remove what the industry calls a 'competitive disadvantage' for the UK's international trade and tourism.[197]

Environmental campaigners agree with the industry to the extent that they believe that the way aviation is currently taxed is inequitable and

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194 2nd EIB climate survey, 14 January 2020 (accessed on 7 February 2020). However it should be noted that there is considerable uncertainty over whether survey results will lead to the actions they suggest, i.e. whether people will follow through on their claims. E.g. Lies, Damned Lies, and Survey Self-Reports? Identity as a Cause of Measurement Bias, Philip S. Brenner and John DeLamater, Soc Psychol Q, 18 November 2016

195 Behaviour change, public engagement and Net Zero, Imperial College London, 10 October 2019

196 HM Revenue & Customs, Rates for air passenger duty: guidance, April 2019

197 A Fair Tax of Flying Campaign Briefing (accessed on 26 February 2020)

have described APD as a 'blunt instrument' that does not incentivise airlines to fly more efficiently.[198]

Most recently, in the March 2020 Budget, the Chancellor of the Exchequer, Rishi Sunak announced that the government was considering changes to APD.[199]

Several European countries have similar taxes on air travel (summarised in the table: Examples of air passenger taxes in Europe below). The UK currently imposes a higher air passenger tax than any country in the EU.[200]

Table 1: Examples of air passenger taxes in Europe

Country	When introduced	Description of tax
United Kingdom[201]	1994	Up to 2000 miles: €15-87 (£13-78) per passenger ticket, depending on class; >2000 miles: €91-600 (£80-528), depending on class.
France[202]	2020	€1.5 on economy class tickets intra-France and intra-EU; €9 intra-EU business class; €3 outside EU economy class; maximum €18 outside EU business class. **Only applies to outgoing flights.** Corsica and overseas French departments exempt. Tax revenue is allocated specifically to investment in greener transport infrastructure.
Sweden[203]	2018	Between €6 and €40 per ticket, depending on destination.
Germany[204]	2011	For destinations within the EU, European Free Trade Association and third countries within the same distance: €8 per passenger ticket. €23 for destinations <6000 km away; €42 for destinations >6000 km.
Austria[205]	2011	Between €3.50 and €17.50, depending on destination.
Norway[206]	2016	Within Europe €7.4 (NOK 75); outside Europe €20 (NOK 200) per passenger ticket. Excludes some remote regions and Norwegian dependencies.
The Netherlands[207]	2021	€7 on every plane ticket departing from the country. Also up to €3.85 per tonne of cargo (lower rate for quieter aircraft).

198 Leo Murray, Possible, Reducing emissions from air travel, Climate Change Assembly, 9 February 2020
199 HM Treasury, *Budget 2020*, 12 March 2020, para 1.47
201 Rates for Air Passenger Duty, *gov.uk*, 6 April 2019 (accessed on 24 February 2020). Note that quoted rates were introduced on 1 April 2020.
202 France to impose green tax on plane tickets, EURACTIV, 10 July 2019 (accessed on 4 March 2020)
203 Swedish Aviation Tax, FCC Aviation (accessed on 24 February 2020)

Plans to introduce or raise taxes have sometimes been faced with fierce opposition from the aviation industry. In 2019 after the French Government announced its plans to introduce an aviation tax, shares in Air France fell 4% and German competitor Lufthansa's shares also dropped by 14% at the same time.[208]

Later that year, the German Government announced plans to increase taxes on both international and domestic air passenger tickets; the money raised from these taxes would then be used to reduce VAT on train tickets. Airlines for America (A4A) – an interest group that represents US airlines America, Delta and United – have said that the plans violate the US-EU 'Open Skies' Air Transport Agreement and undermine CORSIA.[209]

The EU's carbon border tax

In July 2020 the European Commission opened a consultation on a Carbon Border Adjustment Mechanism (CBAM), proposed as part of the EU Green Deal. The aim of the CBAM is to reduce the risk of carbon leakage by "putting a carbon price on imports of certain goods from outside the EU".[210] The direct impact this tax could have on aviation is not yet clear but it may have some impact on e.g. freight carriers and may affect fuel prices. More details are likely to be announced in 2021.

Aviation fuel tax

While road fuel is charged excise duty, which represents a large proportion of the pump price paid by motorists, aviation kerosene used in jet engines is exempt from tax.[211]

The 1944 Convention on International Civil Aviation – the 'Chicago Convention' – establishes the legal framework for international civil aviation. Article 24 of the convention requires all contracting states not to charge duty on aviation fuel not already onboard any aircraft that has arrived from another contracting state.

ICAO publishes detailed policy guidance on airport and air navigation services charges. It notes that the tax exemption is generally extended to fuel taken on board by aircraft:

> … it is the common practice of many States with respect to aircraft engaged in international transport…on a basis of

203 Swedish Aviation Tax, FCC Aviation (accessed on 24 February 2020)
204 German Aviation Tax, FCC Aviation (accessed on 24 February 2020)
205 Austrian Air Transport Levy, FCC Aviation (accessed on 24 February 2020)
206 Norwegian Air Passenger Tax, FCC Aviation (accessed on 24 February 2020)
207 Dutch Aviation Tax, FCC Aviation (accessed on 24 February 2020)
208 France to impose green tax on plane tickets, EURACTIV, 10 July 2019 (accessed on 4 March 2020)
209 US airlines attack Germany's planned air ticket tax, EURACTIV, 4 November 2019 (accessed on 18 February 2020)
210 EU Green Deal (carbon border adjustment mechanism), European Commission (accessed on 2 September 2020)
211 Aviation: Open Skies, Commons Library Briefing Paper CBP-SN00455, 7 April 2010

> reciprocity, to exempt from or refund taxes on fuel and lubricants taken on board at the final airport in that customs territory.[212]

Over the years, the exemption of airlines to aviation fuel tax has proved hugely controversial. While some countries do impose a fuel tax on *domestic* flights, including Canada, Japan, Saudi Arabia and the US[213] , the UK does not. The Netherlands, Belgium, Luxembourg, France, Sweden and Germany have previously indicated that they are open to introducing a kerosene tax on flights entering their shared airspace.[214]

Opponents to aviation fuel taxes often cite concerns that it could lead to an increase in 'tankering', where airlines refuel where it is cheaper to do so. This would likely lead to increased emissions overall.[215] Further to concerns over tankering, unilateral moves by the UK to impose a duty on this type of fuel would be contrary to international agreements (e.g. CORSIA).[216] The Government's *Aviation 2050* strategy document, published in December 2018 makes no mention of the possibility of taxing aviation fuel.[217]

Proponents of other forms of aviation taxation, such as a frequent flyer levy, suggest that introducing an aviation fuel tax raises problems of equity, with the tax falling hardest on those from lower incomes who fly infrequently.[218]

More information on taxing aviation fuel can be found in Commons Library Briefing: Taxing aviation fuel.

Levies on frequent flyers

In 2013, only 15% of people took 70% of all flights from the UK and 52% of UK residents took no flights at all.[219] Therefore, proposals to amend or increase taxation on air travel are often met with equity concerns.

A number of organisations have proposed a form of frequent flyer levy (FFL) to tackle the environmental impacts of flying in what they deem an equitable way,[220] and the CCC has suggested that an FFL could be one option for managing demand for air travel.[221]

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212 Policies on Charges for Airports and Air Navigation Services (Doc 9082), ICAO, 3rd ed. 2000
213 Jet fuel tax hopes lifted by leaked EU report, EURACTIV, 13 May 2019 (accessed on 24 February 2020)
214 German Greens want to ban domestic flights by 2035, EURACTIV, 24 July 2019 (accessed on 24 February 2020)
215 *Twelfth report*, HC 1718, 4 December 2006 pp37-8.
216 Taxing aviation fuel, Commons Library Briefing Paper CBP-8190, 22 October 2019
217 HM Government, *Aviation 2050 The future of UK aviation: A consultation*, **Cm 9714**, Dec 2018
218 Progressive Ticket Tax - Frequent Flyer Levy, stay-grounded.org (accessed on 26 February 2020)
219 Do 15% of people take 70% of flights? Full Fact, 25 November 2016 (accessed on 7 February 2020)
220 Progressive Ticket Tax - Frequent Flyer Levy, stay-grounded.org (accessed on 26 February 2020)
221 Net-zero and the approach to international aviation and shipping emissions: Letter from Lord Deben to Grant Shapps, Committee on Climate Change, 24 September 2019

In a report for the CCC, Dr Richard Carmichael of Imperial College London argued for a version of an FFL on the following grounds:

> In contrast to an aviation fuel tax, which would increase air fares for all passengers at the same rate, research suggests that a levy aimed at excessive flying by frequent flyers could have popular support.[222]

A YouGov survey commissioned by proponents of a version of an FFL showed that 56% of people surveyed thought that replacing APD with an FFL was at least 'somewhat fair'.[223] At the 2020 Citizens' Assembly on Climate Change, 80% of participants supported a frequent flyer levy. Specifically they recommended that "frequent fliers and those who fly further should pay more".[224] 80% of participants voted for this option over a carbon tax on all flights, and a tax that increases as people fly more often (but not as they fly further).

Various versions of the levy have been proposed, including a Progressive Ticket Tax, and an air miles levy.

No FFL measure currently exists for aviation in any country. All existing instruments tax every ticket/person equally.

5.3 Incentivising and improving air transport alternatives

Improvements and incentives for rail travel can reduce demand for short-haul flights. This is particularly relevant for domestic routes and travel between European countries.[225] In a report for the CCC, Dr Richard Carmichael from Imperial College London suggested that the following policy measures could be implemented to incentivise the use rail and bus routes:

- Invite operators to offer new low-fare, high-speed inter-city rail services to shift journeys from car and air to rail (as planned for London-Edinburgh from 2021)
- Require rail and bus companies to introduce reduced-price season tickets/passes for part-time workers
- Reopen disused rail lines and withdrawn bus services where demand exists, or could develop, to reduce car dependency
- Finance a programme of investment across the whole of rail and bus networks to improve services and reduce and simplify fares[226]

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222 Behaviour change, public engagement and Net Zero, Imperial College London, 10 October 2019
223 Public attitudes to tackling aviation's climate change impacts, 10:10 Climate Action, January 2019
224 *The Path to Net Zero*, Climate Assembly UK, September 2020, p 17
225 *Plane Truths: Do the economic arguments for aviation growth really fly?* New Economic Foundation, 2000
226 Behaviour change, public engagement and Net Zero, Imperial College London, 10 October 2019, p24-25

Virtual attendance

Tele-conferencing and telepresence technologies offer an alternative to some work-related travelling and measures to promote these alternative ways of working and doing business could deliver economic savings and benefits for well-being as well as emissions reductions.[227]

The coronavirus outbreak has caused a dramatic increase in the use of virtual software for business. Commentators have suggested that the global pandemic may have a lasting effect on the way business interactions are conducted.[228]

5.4 Airport expansion and climate goals

The Government has said that it supports airports throughout the UK making best use of existing runways, as along as environmental issues are addressed::

> Airport expansion is a core part of boosting our global connectivity and levelling up across the UK. The Government takes seriously its commitments on the environment and the expansion of any airport must always be within the UK's environmental obligations.[229]

Proposed airport expansions across the UK have been the subject of debate for decades. The aviation industry argue that the lack of airport expansion means that airports are over-congested and that the UK loses out on trade and business. However, a number of expansion proposals (including at London Heathrow[230], Bristol and London Stansted airports) have been rejected due to concerns the environmental impacts of expansion (climate change, noise, air pollution).[231] Notably, a ruling by the Court of Appeal in February 2020 cast doubt on plans for a third runway at Heathrow. Judges ruled that the proposed expansion was unlawful as the procedures followed by the Secretary of State did not take into account climate commitments, but that in future, the expansion could go ahead if shown to be compatible with UK climate policy.[232] Heathrow Airport appealed the decision and in December 2020 the Supreme Court overturned the earlier judgment[233], which means the project can now seek planning permission via a Development Consent Order.

A moratorium on airport expansion has been proposed by environmental and community campaign groups both as a demand management mechanism to reduce emissions from aviation, and to

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227 Behaviour change, public engagement and Net Zero, Imperial College London, 10 October 2019, p36
228 Coronavirus Will Change the World Permanently. Here's How. Politico Magazine, 19 March 2020
229 Department for Transport, *Decarbonising Transport: Setting the Challenge*, para 2.49
230 HCWS135, 27 February 2020
231 DEBATE: Should the Heathrow expansion go ahead?, City A.M., 28 February 2020 (accessed on 3 March 2020)
232 Climate campaigners win Heathrow expansion case, BBC, 27 February 2020 (accessed on 3 September 2020)
233 R (on the application of Friends of the Earth Ltd and others) (Respondents) v Heathrow Airport Ltd (Appellant), 16 Dec 2020

prevent increases in air pollution and noise in local communities.[234] However, the aviation industry argues that if airports are not expanded, congestion will increase, leading to increased fuel consumption during holding and therefore increased emissions.

[234] Groups write to Government asking for a moratorium on airport expansion planning applications, airportwatch.org.uk, 5 November 2019 (accessed on 3 September 2020)

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