Heathrow Airport Limited

Heathrow's North-West Runway

Carbon Emissions: Cruise

11 July 2014

AMEC Environment & Infrastructure UK Limited

4b

Non-Technical Summary

This Carbon report for aircraft cruise CO_2 emissions has been prepared by AMEC Environment & Infrastructure Limited on behalf of Heathrow Airport Limited (HAL). To meet the growing need for additional airport capacity identified by the Airports Commission, HAL has proposed an extension to the existing Heathrow Airport. The proposed development would include:

- A 3,500m runway to the north-west of the existing Airport;
- Two new terminal buildings;
- Aircraft movement areas and taxiways;
- Various aircraft stands (pier serviced stands and remote stands);
- Car parking; and
- Ancillary uses.

Further details of the development can be found in HAL's submission to the Airports Commission[1].

The Airports Commission's Interim Report and the Committee on Climate Change found that providing capacity for at least one additional runway in the South East – and hence a third runway at Heathrow – is consistent with meeting long-term UK climate change targets. This assessment has focused on the impacts of additional flights as the most significant carbon implication of providing additional capacity.

Cruise CO_2 Emissions

A "bottom-up" detailed calculation of emissions due to known technology, combined with "top down" scaling for operational improvements and use of biofuels, have been used to estimate carbon emissions of flights departing Heathrow in 2030. In 2010, emissions due to departing aircraft at all heights (cruise and LTO) were 18.8 million tonnes (megatonnes – Mt) CO_2[2,3] of which cruise emissions are estimated as 18.2 Mt CO_2. With the proposed third runway development in 2030 (570,000 Air Transport Movements (ATMs), 103.6 mppa), cruise emissions would increase to 22.3 - 24.4 Mt CO_2. These figures take into account the entry of more fuel-efficient aircraft into the fleet using Heathrow, together with more efficient use of airspace to minimise fuel burn and use of sustainable

[1] Heathrow (2014) Taking Britain further – Heathrow's plan for connecting the UK to growth.

[2] UK DfT (2013) Aviation Forecasts. January 2013.

[3] The emissions for 2010 may be reduced below the planned emissions due to the Icelandic volcanic eruption and the resulting ash cloud and reduction in flights.

alternative fuels. Looking further ahead to 2050, there becomes a higher degree of uncertainty associated with making projections as the implementation of new technologies is more difficult to predict. Therefore a “top down” calculation has been made to estimate cruise emissions in 2050. The top down method applies the range of reduction figures developed by Sustainable Aviation (SA) and the Committee on Climate Change (CCC), which take into account the reduction in emissions due to more efficient airspace use, improvements in fuel efficiency due to new airframe and engine technology and use of sustainable alternative fuels. This yields an estimate of 17.6 Mt CO_2 in 2050, using the SA CO_2 Roadmap, and 25.0 Mt CO_2 by the CCC Likely forecast, for operation of 3RNW with 740,000 ATMs and 130.3 mppa[4]. This means the forecast cruise emissions in 2050 contribute between 47% and 67% of the 37.5 Mt CO_2 target figure set by the previous government for emissions from UK aviation in 2050[5]. For context, in 2010, emissions from flights due to departing aircraft from Heathrow at all heights (cruise and LTO) were 18.8 million tonnes (megatonnes – Mt) CO_2[2,3]. This represented 57% of the total emissions from UK aircraft. Therefore, assuming flights from other UK airports benefit from similar technologies and practices, using either of the emission reduction forecast scenarios, the UK target for CO_2 from aviation in 2050 can be met.

[4] Taking Britain further, section 5.7 gave 23.3 Mt CO_2 in 2030 (570,000 ATMs), which was forecast to be 15.4 Mt CO_2 in 2050. The emissions given above for 2050 are for 740,000 ATMs.

[5] Committee on Climate Change (2009) Meeting the UK aviation target – options for reducing emissions to 2050. December 2009.

Abbreviations

ACI	Airports Council International
ATMs	Air Transport Movements
CAA	Civil Aviation Authority
CCC	Committee on Climate Change
CO_2	Carbon dioxide
CO_2e	Carbon dioxide equivalent
EEA	European Environment Agency
EMEP	Cooperative programme for monitoring and evaluation of long-range transmission of air pollutants in Europe
EU ETS	EU Emission Trading Scheme
GCD	Great-circle distance
GHG	Greenhouse gases
GSE	Ground Support Equipment
ICAO	International Civil Aviation Organization
LTO	Landing and Take-Off cycle
mppa	Million passengers per annum
SAF	Sustainability Appraisal Framework
UNFCCC	United Nations Framework Convention on Climate Change

Contents

1. Introduction

This Carbon Footprint report has been prepared by AMEC Environment & Infrastructure Limited on behalf of Heathrow Airport Limited (HAL). To meet the growing need for additional airport capacity, HAL has proposed an extension to the existing Heathrow Airport[6]. The proposed development would include:

- A 3,500m runway to the north-west of the existing Airport;
- Two new terminal buildings;
- Aircraft movement areas and taxiways;
- Various aircraft stands (pier serviced stands and remote stands);
- Car parking; and
- Ancillary uses.

Further details of the development can be found in HAL's submission to the Airports Commission[6].

This report provides the technical assessment and details underlying the Carbon strategy presented in Volume 1 of HAL's submission to the Airports Commission[6], as it pertains to cruise. Heathrow's objectives and approach to carbon management are described in sections 1.4 and 1.5 respectively.

Section 2 of the report then describes the legislative and policy context relevant to the assessment. Section 3 describes the methodology, data and assumptions used. The UK baseline and Heathrow baseline carbon emissions are given in section 4. In section 5 the carbon footprint due to the development scenarios is given, including future projections to 2050. Conclusions are contained in section 6.

1.1 Greenhouse Gases

Only emissions of carbon dioxide (CO_2), have been considered in this report, as the UK target for emissions from aviation is a target for CO_2, not overall greenhouse gases that would be expressed as CO_2e.

1.2 Sources of Emissions

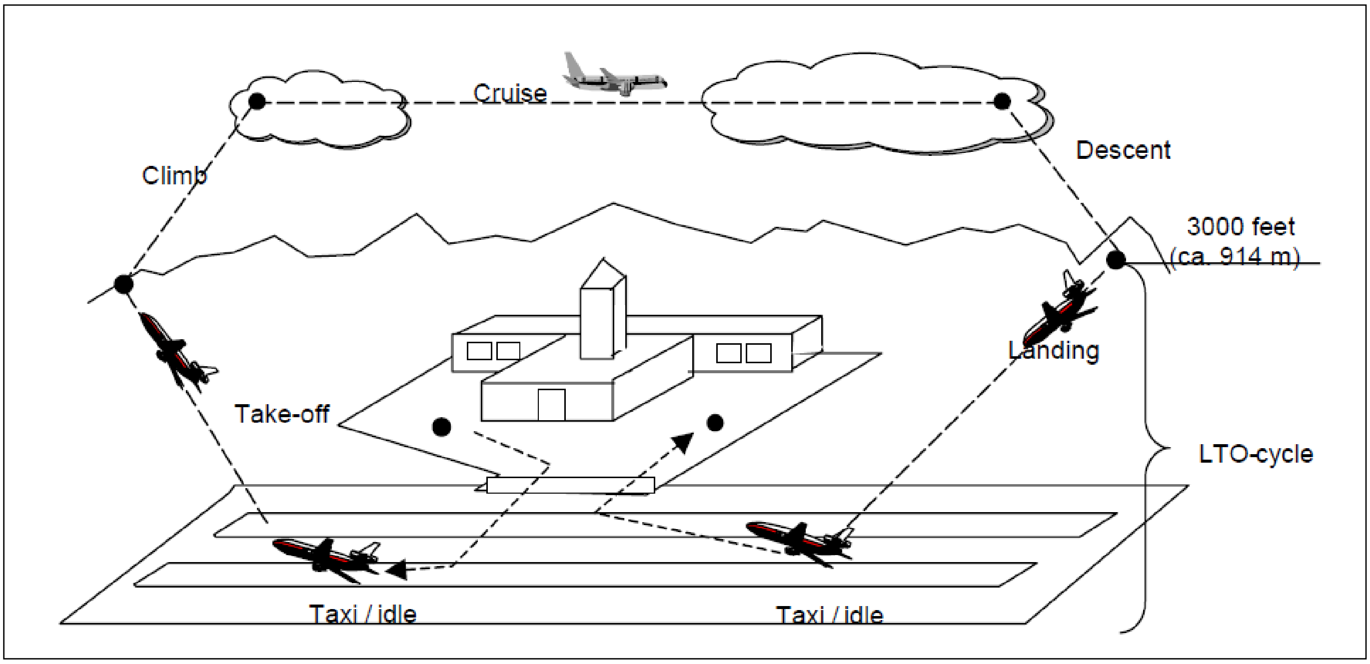
Changes in carbon emissions under different scenarios have been calculated for the following emission sources:

- Aircraft in the air above 3,000ft, which are referred to in this report as "cruise" emissions.

[6] Heathrow (2014) Taking Britain further – Heathrow's plan for connecting the UK to growth

Figure 1.1 is a schematic taken from the EMEP/ European Environment Agency (EEA) Guidebook[7] showing the cycle a plane follows from taxiing out from the airport stands, take-off roll (on the ground), take-off (above ground level), climb, cruise, approach, landing (above ground), landing roll (on the ground), and taxi-in. Those parts of the cycle that take place below 3,000 ft (914m) are referred to as the landing and take-off (LTO) cycle. Those emissions that take place above 3,000 ft comprise climb, cruise and descent and are referred to collectively in this report as "cruise" emissions. The methodology used to calculate emissions from cruise is described in section 3.2.

Figure 1.1 Schematic of the Phases of Aircraft Flight



1.3 Traded and Non-traded Emissions

The traded sector of emissions, which is based on the UK's share of the EU Emissions Trading System (EU ETS) covers the following sectors[8]:

- Carbon dioxide (CO_2) from
  - Power and heat generation;
  - Energy-intensive industry sectors including oil refineries, steel works and production of iron, aluminium, metals, cement, lime, glass, ceramics, pulp, paper, cardboard, acids and bulk organic chemicals;

[7] EMEP/EEA Guidebook 2009, 1.A.3.a, 1.A.5.b Aviation, updated December 2010, http://eea.europa.eu/emep-eeaguidebook

[8] http://ec.europa.eu/clima/publications/docs/factsheet_ets_en.pdf

- Civil aviation emissions within European regional airspace;

- Nitrous oxide (N_2O) from production of nitric, adipic, glyoxal and glyoxlic acids; and
- Perfluorocarbons (PFCs) from aluminium production.

The non-traded sector covers everything else such as road and rail transport, agriculture and emissions from buildings.

1.4 Heathrow's Objectives

The Airports Commission's Interim Report and the Committee on Climate Change (CCC) have found that providing capacity for at least one additional runway in the South East – and hence a third runway at Heathrow – is consistent with meeting long-term UK climate change targets. This assessment has focused rightly on the impacts of additional flights as the most significant carbon implication of providing additional capacity. The assessment therefore aims to identify measures that will minimise carbon emissions from:

- Aircraft flying to their destinations (above 3,000ft);

The strategy for minimising operational energy use at the airport is described in the Technical Appendix to *Chapter 5.8, a resource efficient Heathrow*[9].

1.5 Heathrow's Approach to Carbon Management

Heathrow's carbon management strategy reflects the degree of control that HAL, as an airport operator, has over the many sources of emissions associated with Heathrow. These can be defined in three categories – those that HAL can 'control', those HAL can 'guide' and those HAL can 'influence'.[10]

HAL 'controls' CO_2 emissions where it has operational and/ or financial control – for example, in relation to on-airport energy use - and has set a target to cut CO_2 emissions from fixed assets by 34% on 1990 levels by 2020[9].

HAL 'guides' CO_2 emissions by agreeing with airport companies and staff the policies, standards and operating procedures used to manage emissions within and close to the airport boundary.

HAL 'influences' CO_2 emissions at and beyond the airport by engaging with stakeholders to develop and promote solutions for managing emissions. Examples include:

- Heathrow has a long-standing policy position going back to 2002 supporting the inclusion of aviation in emissions trading in the EU Emissions Trading System as a stepping stone to a global cap and trade

[9] HAL (2014) See Chapter 5.8 A resource efficient Heathrow in Volume 1 of Taking Britain further, Heathrow's plan for connecting the UK to growth http://your.heathrow.com/britainsheathrow/downloads/

[10] See http://www.heathrowairport.com/static/Heathrow/Downloads/PDF/LHR_Climate_brochure.pdf for details

system. This is the most economically efficient and environmentally effective way to abate carbon emissions.

- Heathrow were founder members of the Aviation Global Deal Group, which developed a policy approach for managing aviation's global emissions and directly influenced negotiations at the International Civil Aviation Organisation (ICAO) United Nations Framework Convention on Climate Change (UNFCCC);

- As members of the Prince of Wales's Corporate Leaders Group on Climate Change, Heathrow has been able to lobby UK and international policy-makers on climate policy, and has been a strong supporter of mandatory carbon reporting; and

- Heathrow has made significant investment in rail infrastructure such as £750 million for building and operating Heathrow Express services to drive a shift from car to lower carbon rail journeys to the airport.

Since 2010, Heathrow's carbon management performance has been recognised by the Airports Council International (ACI) and has been certified at Level 3 "Optimisation" by ACI's Airport Carbon Accreditation Scheme[11]. This scheme includes 4 levels of classification: 1 – Mapping; 2 – Reduction; 3 – Optimisation; and 4 – Neutrality.

[11] Airport Carbon Accreditation is an independent programme administered by ACI. Airports must have carbon footprints independently verified in accordance with ISO14064 (Greenhouse Gas Accounting). Evidence of this must be provided to the administrator together with all claims regarding carbon management processes, which must also be independently verified.

2. Legislative and Policy Context

The Climate Change Act 2008[12] set the commitment of the UK to reduce its net GHG emissions by 80% below 1990 levels by 2050 and requires the Government to establish 5-year carbon budgets. Emissions by international aviation and international shipping were initially left out of carbon budgets (and the 2050 target) when the Climate Change Act became law. They are not included in the 2050 target, for example, as set out in the Government's November 2011 Carbon Plan[13], which sets out how the UK will achieve decarbonisation within the framework of the UK energy policy and make the transition to a low carbon economy. Under the Act, a decision on the inclusion of international aviation and shipping was expected by the end of 2012. The recently published Aviation Policy Framework[14] sets the new date for this decision to be June 2016, to allow international agreements relating to the EU ETS (Emissions Trading Scheme) to be resolved.

By June 2016, the energy policy framework will also consider whether to adopt the previous administration's 2050 aviation CO_2 target, which was to reduce CO_2 emissions below the 2005 level of 37.5Mt. This target refers to emissions from cruise and LTO CO_2 that constitute 99% of the GHG emissions from aviation, rather than greenhouse gases in total. Due to secondary chemical processes, GHG emissions from non-CO_2 gases are difficult to measure and mitigate. Hence, the UK Government's policy on climate change focuses on targeting CO_2 emissions and developing a national strategy, while aiming for specific international agreements at European and global level. The influence of the aviation sector is global (e.g. emissions from international flights occurring in the UK, departing from or arriving to other destinations) and action taken only nationally could lead to undesired collateral effects elsewhere (e.g. the price increase that the routes from a country tackling GHG emissions would influence passengers to choose other routes, thus increasing CO_2 emissions in another area). However, no legally binding measures have come into force so far[2].

Taking into account the aviation sector as a whole (domestic and international) and all GHG emissions, it accounts for 6% of the total UK GHG emissions[2]. Although significant steps are being taken to reduce carbon emissions within the aviation sector, abatement costs for aviation remain relatively high compared to other sectors. As a result, as other sectors decarbonise more quickly, aviation's share of total GHG emissions is likely to increase. However, including aviation in emissions trading provides aviation with access to lower cost carbon abatement from other sectors. This allows the aviation industry to grow while funding abatement in other sectors through the carbon market. [2].

[12] HM Government (2008) *Climate Change Act 2008*, http://www.legislation.gov.uk/ukpga/2008/27/pdfs/ukpga_20080027_en.pdf

[13] HM Government (2011) *The Carbon Plan: Delivering our low carbon future*, HM Government, December 2011 https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/47613/3702-the-carbon-plan-delivering-our-low-carbon-future.pdf

[14] Department for Transport (2013) *Aviation Policy Framework*, HM Government, March 2013. https://www.gov.uk/government/publications/aviation-policy-framework

A brief summary of measures at global level includes:

- The UN International Civil Aviation Organization (ICAO) is making progress towards the goal of global regulation of aviation emissions. It has committed to an international CO_2 standard for aircraft by 2016 and has a set a goal for carbon-neutral growth by 2020. ICAO has undertaken a number of studies into market-based-measures since 2001 and at its 38th session (24 September – 4 October 2013), the ICAO Assembly decided to develop a global market-based measure scheme for international aviation[15]. The UK Government supports the development of global market-based measures[14].

- The International Air Transport Association (IATA) has adopted a set of targets to mitigate CO_2 emissions from air transport[16]. The targets are: an average improvement in fuel efficiency of 1.5% per year from 2009 to 2020; a cap on net aviation CO_2 emissions from 2020 (carbon-neutral growth); and a reduction in net aviation CO_2 emissions of 50% by 2050, relative to 2005 levels.

At the EU level, there are several legally binding measures, alongside research and development to reduce emissions at source as well as the modernisation of aircrafts and air traffic management. The two main strategies at this level are the EU Emissions Trading System (EU ETS) and the creation of a Single European Sky Programme (SESP)[14]. In order to comply, airlines will have to reduce their own emissions or purchase credits from other sectors that reduce CO_2 emissions more easily and/or at lower costs.

As all sectors are part of the EU ETS scheme, the possibility of those sectors emitting less to sell their surplus credits to higher emitting sectors is key for its success, and is especially relevant for the aviation sector, for which abatement costs are expected to be very high, at least in the short/ medium term[14]. The current scope of EU ETS is the EU target of 20% GHG emissions reduction by 2020. As part of it, the UK aviation sector expects to reduce its emissions by 560Mt CO_2 on aggregate in the period 2012-2020. A long-term scope has not been established yet but the Government predicts it to be used for specific objectives so that all sectors can contribute to them accordingly[14]. As a consequence of the UN ICAO discussions on an international agreement, the European Commission decided to postpone these obligations for one year for flights in and out the EU, while flights within the EU would have to comply[17].

The second pillar of the strategy is the SESP, which would increase the efficiency of airspace use. UK commitments to SESP have resulted in the creation of the UK and Ireland Functional Airspace Block (FAB), which provided £37.5 million in savings in the period 2008-2011, including savings in unspent fuel. The UK medium term aim is to create a FAB covering a wider area[14].

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[15] Resolutions adopted by the Assembly, Assembly – 38th Session Montréal, 24 September—4 October 2013, International Civil Aviation Organization, Provisional edition, November 2013, http://www.icao.int/Meetings/a38/Documents/Resolutions/a38_res_prov_en.pdf

[16] RESOLUTION ON THE IMPLEMENTATION OF THE AVIATION “CNG2020” STRATEGY, IATA https://www.iata.org/pressroom/pr/Documents/agm69-resolution-cng2020.pdf

[17] Strasbourg, COM(2012) 697, 2012/328 (COD), *Proposal for a DECISION OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL derogating temporarily from Directive 2003/87/EC of the European Parliament and of the Council establishing a scheme for greenhouse gas emission allowance trading within the Community* http://ec.europa.eu/clima/policies/transport/aviation/docs/com_2012_697_en.pdf

In the UK, the Civil Aviation Authority (CAA) has set an airspace Strategy for the future years, with proposed measures such as enhancing the queue management system at busy airports or changes in some routes to improve efficiency. The total benefits of this future strategy are projected to be between £1.88-£2.45 billion between 2013-2030 (net present value, 2011 prices).

Sustainable Aviation, the coalition of airlines, manufacturers, airports and NATS, which develops practical and policy solutions for cleaner, quieter, smarter flying, published a detailed 2050 CO_2 Roadmap in 2012. The Roadmap projects that the UK can accommodate significant growth in aviation by 2050 – a doubling of air traffic – without a substantial increase in gross emissions. This can be achieved through a combination of new aircraft and engine technology, operational efficiencies, and sustainable alternative fuels. It also confirms the industry's support for internationally agreed carbon trading to cut net CO_2 emissions to 50% of 2005 levels in line with IATA's global industry goal.

3. Methodology, Input Data and Assumptions

The following sections describe briefly the scenarios modelled, the methodology used in this assessment, the input data used and assumptions made.

3.1 Heathrow Scenarios

Table 3.1 lists the possible future scenarios for Heathrow.

Table 3.1 Runway, ATM and Passenger Scenarios

Year	Scenario	ATMs	Passenger numbers (mppa)	Number of employees
2010	2R	477,000	69.4	76,000
2030	3RNW	570,000	103.6	80,000
2050	3RNW	740,000	130.3	105,000

Figure 1.1 shows a schematic of the cycle a plane follows from taxiing out from the airport stands, take-off roll (on the ground), take-off (above ground level), climb, cruise, approach, landing (above ground), landing roll (on the ground), and taxi-in. Those parts of the cycle which take place above 3,000 ft (914m): climb, cruise and descent are referred to collectively in this report as "cruise". The methodology to calculate emissions due to cruise is described in the following sections.

3.2 Overview of Methodology

In estimating emissions from cruise in 2030 and 2050, the following effects which change emissions of CO_2 have been taken into account:

- **ATM and Operations**: improved operational practices to reduce time in the air and hence reduce fuel used;
- **Sustainable fuels**: increased use of biofuels; and
- **Improved fleet fuel efficiency**: improved fuel efficiency due to the introduction of new aircraft and engines.

"Top down" factors for the likely impact of these effects on the UK-wide fleet have been calculated by various organisations and these are described in section 4. The "top down" scaling has been used for all three effects for the periods from 2010 to 2030, and 2030 to 2050, with the exception of fuel efficiency between 2010 and 2030, for which a "bottom-up" calculation has been used to provide a better estimate. The "bottom-up" calculation is described in the section 3.3.

Table 3.2 summarises the approaches used.

Table 3.2 Summary of Approach to Calculation of Cruise Emissions in 2030 and 2050

Effect	2010 to 2030	2030 to 2050
ATM and Operations	Top down scaling	Top down scaling
Sustainable fuels	Top down scaling	Top down scaling
Fuel efficiency	Bottom-up calculation	Top down scaling

3.3 Aircraft Cruise Emissions to 2030

The aircraft fleet used to calculate cruise emissions is the same as that used in the air quality and noise chapters. Whereas emissions during the LTO are calculated using fuel consumption and emission indices from the ICAO databank for engines, the ICAO databank does not include emission indices or fuel burn for cruise. Cruise emissions in 2030 have, therefore, been calculated following the Tier 3 methodology for NFR (Nomenclature for Reporting) category 1.A.3 as described in the EMEP/ EEA (European Environment Agency) Guidebook 2013[18], and using the Eurocontrol Small Emitters Tool version 5.02[19] to calculate emissions for the whole flight. The Small Emitters Tool has been approved for use by the European Commission as part of the EU Emissions Trading Scheme (EU ETS). It is based on individual flights, aircraft type used, actual route length and statistically sound fuel consumption relationships. It has been used for the whole flight emissions as it includes more recent aircraft than the EMEP/EEA spreadsheet and is updated on a regular basis in order to improve its accuracy.

The basis of the methodology is the calculation of total fuel used in travelling from the origin to the destination airport, subtraction of an estimate of LTO emissions (from the EMEP/ EEA Guidebook). Hence, the remainder gives the cruise emissions.

The data supplied for calculation of cruise emissions comprised the schedule for one busy day of aircraft movements for a 2030 3RNW (570,000 ATMs) scenario. The schedule is summarised in **Table A.1** in **Appendix A**.

The following assumptions have been made whilst undertaking this assessment of aircraft cruise emissions:

- The journey distances for each ATM are based upon the great-circle distance (GCD), i.e. the shortest distance between any two points on the surface of a sphere measured along a path on the surface of the

[18] EMEP/EEA Guidebook 2013, 1.A.3.a, 1.A.5.b Aviation, December 2013, http://www.eea.europa.eu/publications/emep-eea-guidebook-2013

[19] http://www.eurocontrol.int/articles/small-emitters-tool

sphere, as opposed to going through the sphere's interior, calculated from the locations of Heathrow airport and the corresponding starting or final destination airport given in the flight schedule. Consequently, this methodology does not take into account any stop-overs en-route to the final destination, for instance, for refuelling. It attributes the CO_2 emissions between Heathrow and the starting or final destination airport to the cruise emissions;

- An increase of 8% has been made to the baseline GCD as the actual distance flown is likely to be longer than the GCD due to routing not following the shortest route and stacking at airports during periods of heavy congestion[2];

- Cruise CO_2 emissions from arriving aircraft have not been calculated or reported, as these are attributed to the airport from which they depart, so to include them would be double-counting those emissions;

- The fuel burn estimate is converted to CO_2 emissions by applying a conversion factor of 3.15 for aircraft having "Jet" or "Turboprop" as engine type in ICAO Doc. 8643[20], and a conversion factor of 3.10 for aircraft having "Piston" as engine type in ICAO Doc. 8643;

- **Table A.1** in **Appendix A** details the frequency of movement for each assumed aircraft type;

- The future schedule includes destination airport codes that correspond to regions rather than airports. Where these exist, the average destination (in terms of distance from Heathrow) for the future market has been adopted, as outlined in **Table A.2** in **Appendix A**; and

- The CO_2 emissions per annum were calculated from the schedule for a busy day by factoring the busy day emissions by the ratio of annual ATMs to the number of ATMs provided in the busy day schedule.

3.3.1 2030 Fleet

The information below is that upon which our 2030 calculation for the CO_2 emissions during cruise is based for new and future aircraft. For the two aircraft which are not in the Eurocontrol Small Emitters database, the manufacturers' statements on fuel consumption have been used. The assumptions used in this report are listed in **Table 3.3.**

[20] ICAO 2012, Doc. 8643 Aircraft Type Designators, Edition 40.

Table 3.3 Assumptions about Cruise Emissions from New and Future Aircraft

IATA code of aircraft in the schedule	ICAO code of representative aircraft
N19, N20 and N21 (new generation 319, 320 and 321)	A319, A320 and A321 in Small Emitters Tool - factor applied to reduce fuel by 15%. Note 1.
788 and 789	B788 in Small Emitters Tool
388	A388 in Small Emitters Tool
351, 358, 359 and 35X	B788 in Small Emitters Tool - factor applied to reduce fuel by 25%. Note 2.
778 and 779	B77L in Small Emitters Tool
7ZZ (next generation Code E aircraft), 7XX (stretched new generation Boeing B777)	B77L in Small Emitters Tool
E90 and E95	E190 in Small Emitters Tool

Notes:

1. The A320neo "new engine option" incorporates many innovations, including latest generation engines and large Sharklet wing-tip devices, which together deliver 15 percent in fuel savings http://www.airbus.com/newsevents/news-events-single/detail/airbus-first-a320neo-reaches-completion/

2. A350 XWB will provide a 25% step-change in fuel efficiency compared to its current long-range competitor http://www.a350xwb.com/#eco-efficient/less-is-more

4. Baseline and Future Base Cases

4.1 UK Aviation

CO_2 emissions from the UK aviation sector in 2010 have been calculated by the DfT[2] as 33.3Mt. This includes the LTO for passenger and freighter domestic flights; and emissions from international passenger and freighter flights departing UK airports or on the ground in the UK. It does not include international arrivals, emissions from over-flights passing through UK space, British aircraft departing and arriving at non-UK airports, non-commercial flights or emissions from secondary travel from and to the airport.

4.1.1 Forecasts to 2050

Projections for the impact of operational practices, fleet fuel efficiency and the use of biofuels on emissions of CO_2 have been published by the Department for Transport, Sustainable Aviation (SA)[21] (a body governed by representatives from signatory organisations, that include 90% of UK airlines, airports and air navigation service providers, as well as all major UK aerospace manufacturers) and by the UK Committee on Climate Change (CCC)[22]. All three organisations predict that CO_2 emissions from UK aviation in 2030 will be around 29%-34% higher than in 2010. However, the DfT's estimates, which do not include the construction of a new runway in the UK and the stimulus to reduction in CO_2 emissions that would bring, are pessimistic concerning the use of biofuels and improved operational practices in 2050. The SA and CCC forecasts by comparison have been undertaken to demonstrate how the 2050 target for CO_2 from aviation can be achieved with the growth that an additional runway would bring. The SA and CCC forecasts have therefore been used for the top down scaling.

Table 4.1 shows the DfT's expected CO_2 emissions from the UK aviation sector under the three considered demand scenarios with growth constrained by airport capacity, i.e. assuming no new runways are built. Considering the central growth scenario, the emissions could rise by circa 41% from 2010 to 2050. In the low and high growth scenarios the emissions are predicted to increase initially and then decrease.

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[21] Sustainable Aviation (2012) CO_2 Road-Map, March 2012, http://www.sustainableaviation.co.uk/wp-content/uploads/SA-CO2-Road-Map-full-report-280212.pdf Figure 13 for carbon reduction factors.

[22] Committee on Climate Change (2012) *Meeting the UK aviation target – options for reducing emissions to 2050* (December 2009). http://downloads.theccc.org.uk/Aviation%20Report%2009/21667B%20CCC%20Aviation%20AW%20COMP%20v8.pdf

Executive Summary http://downloads.theccc.org.uk/Aviation%20Report%2009/21667B%20CCC%20Exec%20Summary%20AW%20v2.pdf Figure ES.6 for carbon reduction factors.

Table 4.1 UK Aviation Emissions Forecast by DfT to 2050, Mt CO_2

Year	Low	Central	High
2010 (actual)	**33.3**	**33.3**	**33.3**
2020	36.3	39.4	42.5
2030	39.7	43.5	48.2
2040	38.7	46.4	56.9
2050	34.7	47.0	52.1

Notes: bold denotes calculation rather than projection, so the values in 2010 are identical.

The *CO_2 Road-Map*, published by Sustainable Aviation**Error! Bookmark not defined.** presents the following assessment of possible improvements for the period 2010 to 2050:

- Air traffic management and operational practices: fuel efficiency could decrease emissions by 9%;
- Introduction of "imminent" generation and subsequent generation aircraft: combined improvement in fleet average fuel efficiency could decrease emissions by 39%; and
- Penetration of sustainable fuels into the global aviation fuel market with 60% life-cycle CO_2 saving per litre of fossil kerosene displaced. Assuming a 25-40% penetration, this is predicted to give an 18% reduction in CO_2 emissions from UK aviation.

The overall improvement forecast by Sustainable Aviation that could be achieved between 2010 and 2050 is, therefore, 54.5% (a carbon intensity reduction factor of 0.455).

The Committee on Climate Change published *Meeting the UK aviation target – options for reducing emissions to 2050***Error! Bookmark not defined.** following the previous government's decision to expand Heathrow airport by building a third runway[23]. It proposes that the following CO_2 reductions can be made between 2005 and 2050:

i. Improvement in fuel efficiency due to evolutionary airframe and engine technology innovation & improved efficiency of air traffic management and operations:

  - Likely improvement in fleet fuel efficiency: -0.8% per annum (fleet averaged values on a seat-km basis).
  - If funding increased and technology innovation accelerated: -1.5% per annum (fleet averaged values on a seat-km basis).

ii. Use of biofuels, assuming an average emissions saving of 50% relative to fossil fuels:

  - Likely: 10% penetration.
  - Optimistic: 20% penetration.
  - Speculative: 30% penetration.

[23] Department for Transport (2009c) Britain's Transport Infrastructure, Adding Capacity at Heathrow: Decisions Following Consultation, January 2009, http://webarchive.nationalarchives.gov.uk/+/http:/www.dft.gov.uk/pgr/aviation/heathrowconsultations/heathrowdecision/

The improvement forecast by the Committee on Climate Change that could be achieved between 2005 and 2050 is, therefore, 35% (likely), 45% (optimistic), 55% (speculative), corresponding to carbon intensity reduction factors of 0.65, 0.55 and 0.45 respectively.

The CCC Likely forecast, the most pessimistic of its forecasts, and the SA CO_2 Roadmap factors, shown in **Table 4.2**, have been used in section 5.3 of this report to estimate reductions due to ATM and Operations and sustainable fuels in 2030, and to calculate the impact of all three effects in 2050 on cruise emissions of CO_2.

Table 4.2 Comparison of CO_2 Reductions Forecast by SA and CC Likely[21]

Effect	Date	SA CO_2 Roadmap	CCC Likely
ATM and Operations*	2050	9%	6%
Sustainable fuels	2030	8%	1%
	2050	18%	5%
Average annual improvement in fleet fuel efficiency	To 2050	1.21%	0.8%

Note: *Half of the reduction due to ATM and Operations has been assumed to be delivered by 2030.

4.2 Heathrow Baseline

The DfT estimated that in 2010, emissions due to departing aircraft at all heights (cruise and LTO) were 18.8 Mt CO_2[2] of which cruise emissions are estimated as 18.2 Mt CO_2.

5. Future Development Carbon Emissions

5.1 Aircraft Mitigation Measures

HAL has proposed the following mitigation for emissions from aircraft:

- Lower emission aircraft will be incentivised by apply emission-based landing charges to encourage operators to use aircraft that are the lowest emitting of their type, and introducing "green slots" where new take-off and landing slots are only given to airlines that are willing to operate the cleanest aircraft; and

- Use of air traffic management and operational practices such as CDM will be progressively increased to reduce time in the air and on the ground and hence reduce emissions.

Heathrow also has a long-standing policy position on the need to include aviation in an emissions trading system, at a European level first as a stepping stone to an internationally agreed global system. Heathrow believes that aircraft emissions can be further reduced by emissions trading, and that this process provides the industry with the most economically-efficient and environmentally-effective way to abate its carbon emissions. By providing aviation with access to carbon abatement from other sectors, not only does aviation benefit from lower abatement costs, but the carbon market is stimulated to drive further abatement. HAL actively promotes policy solutions to incorporate aviation in carbon trading first in Europe and then internationally to reduce net emissions.

HAL has been active for more than a decade influencing CO_2 emissions at and beyond the airport by engaging with stakeholders to develop and promote solutions for managing emissions. Examples include:

- Active participation in Sustainable Aviation to continue to understand how the industry can decouple traffic growth and emissions. The Sustainable Aviation CO_2 emissions roadmap shows how, with the aid of technology, improvements in operational efficiency and increased take up of low-carbon alternative fuels, the level of UK air traffic can more than double without increasing the direct emissions from those flights.

- Membership of the Aviation Global Deal Group, which has developed a policy approach for managing aviation's global emissions and has directly influenced negotiations at the International Civil Aviation Organisation (ICAO) and the United Nations Framework Convention on Climate Change (UNFCCC); and

- As members of the Prince of Wales's Corporate Leaders Group on Climate Change, Heathrow has been able to lobby UK and international policy-makers on climate policy, and has been a strong supporter of mandatory carbon reporting.

5.2 Aircraft Cruise Emissions

The dominant source of carbon emissions is that from aircraft in the cruise phase of flight, the emissions that occur above an altitude of 3,000ft (914m). For that reason, and because Heathrow has little control over these emissions, Aircraft Cruise Emissions have been reported separately from the Heathrow Carbon Footprint, the latter consisting of emissions that Heathrow can more easily Control, Guide and Influence.

A "bottom-up" detailed calculation of emissions due to known technology, combined with "top down" scaling for operational improvements and use of biofuels, have been used to estimate carbon emissions of flights departing Heathrow in 2030. In 2010, emissions due to departing aircraft at all heights (cruise and LTO) were 18.8 million tonnes (megatonnes – Mt) CO_2[2,3] of which cruise emissions are estimated as 18.2 Mt CO_2. With the proposed third runway development in 2030 (570,000 Air Transport Movements (ATMs), 103.6 mppa), cruise emissions would increase to 22.3 - 24.4 Mt CO_2. These figures take into account the entry of more fuel-efficient aircraft into the fleet using Heathrow, together with more efficient use of airspace to minimise fuel burn. Looking further ahead to 2050, there becomes a higher degree of uncertainty associated with making projections as the implementation of new technologies is more difficult to predict. Therefore a "top down" calculation has been made to estimate cruise emissions in 2050 as described earlier in section 4.1.1. The top down method applies the range of reduction figures developed by Sustainable Aviation (SA) and the Committee on Climate Change (CCC), which take into account the reduction in emissions due to more efficient airspace use, improvements in fuel efficiency due to new airframe and engine technology and use of biofuels. This yields an estimate of 17.6 Mt CO_2 in 2050, using the SA CO_2 Roadmap, and 25.0 Mt CO_2 by the CCC Likely forecast, for operation of 3RNW with 740,000 ATMs and 130.3 mppa. This means the forecast cruise emissions in 2050 contribute between 47% and 67% of the 37.5 Mt CO_2 target figure set by the previous government for emissions from UK aviation in 2050[5]. For context, in 2010, emissions from flights due to departing aircraft from Heathrow at all heights (cruise and LTO) were 18.8 million tonnes (megatonnes – Mt) CO_2[2,3]. This represented 57% of the total emissions from UK aircraft. Therefore, assuming flights from other UK airports benefit from similar technologies and practices, using either of the emission reduction forecast scenarios, the UK target for CO_2 from aviation in 2050 can be met.

Table 5.1 summarises the cruise emissions in 2030 (570,000 ATMs, 103.6 mppa) and 2050 (740,000 ATMs, 130.3 mppa).

Table 5.1 Comparison of Aircraft Cruise Emissions Compared to the 2050 National Aviation Emissions Value of 37.5Mt CO_2 (Mt CO_2 per annum)

2030 3RNW (570,000 ATMs, 103.6 mppa)	2050 3RNW (740,000 ATMs, 130.3 mppa)	
	Emissions (Mt CO_2)	Emissions as % of 2050 target
SA CO2 Roadmap		
22.3	17.6	47%
CCC Likely Forecast		
24.4	25.0	67%

In section 5.7 of *Taking Britain further*[1], the carbon emissions from cruise in 2030 (570,000 ATMs, 103.6 mppa) were given as 23.3 Mt CO_2, which lies between the SA and CCC Likely figures given in **Table 5.1** (22.3 and 24.4

Mt CO_2). The forecast emissions in *Taking Britain further* for 2050 were 15.4 Mt CO_2 which was also for 570,000 ATMs, whereas the numbers in **Table 5.1** are for 740,000 ATMs in 2050. Using the SA and CCC Likely assumptions would give a range from 13.6 to 17.7 Mt CO_2.

6. Conclusions

This report presents the work carried out in response to the Airports Commission SAF Appraisal module for Carbon. Carbon emissions due to cruise have been calculated and compared with the national target of 37.5 Mt CO_2 for 2050.

Carbon emissions from aircraft cruise, the emissions that occur above 3,000ft (914m), are the dominant source of aviation emissions. Cruise emissions are predicted to decrease by as much as 33% between 2030 and 2050 due to the introduction of new, cleaner aircraft and biofuels, even though ATMs increase over the same period by 30%.

Box 6.1 summarises the carbon emissions due to cruise that have been calculated.

Box 6.1 Summary of Carbon Emissions

Aircraft Cruise Emissions	
2010 Baseline (477,000 ATMs, 69.4 mppa)	18.2 Mt CO_2
2030 3RNW (570,000 ATMs, 103.6 mppa)	22.3 – 24.4 Mt CO_2
2050 3RNW (740,000 ATMs, 130.3 mppa)	17.6 – 25.0 Mt CO_2

Appendix A
Detailed Input Data

Table A.1 The Selection of Representative Aircraft and Frequency of Movements for a Busy Day Schedule

Aircraft IATA code	2030
	3RNW
319	27
320	56
321	13
351	12
358	18
359	30
388	112
778	51
779	1
788	149
789	157
7XX	96
E95	6
N19	248
N20	427
N21	190
E90	4
35X	58
Grand Total	**1655**

Table A.2 Assumed Destination/ Origins for Regional Airport Codes Provided in Future Market Schedules

Market	Destination	ICAO Code	Airport/City	Country
OM-01 UK	ZUK	BHD	Belfast	UK
OM-03 IRL	ZIR	ORK	Cork	Ireland
OM-04 EU	ZEU	BCN	Barcelona	Spain
OM-05 OSH	ZSH	KEF	Reykjavik	Iceland
OM-06 JP	ZJP	NRT	Tokyo	Japan
OM-07 NA	ZNA	ATL	Atlanta	USA
OM-08 MECA	ZME	RUH	Riyadh	Saudi Arabia
OM-09 EA	ZEA	TPE	Taipei	Taiwan
OM-10 SA	ZSA	HYD	Hyderabad	India
OM-11 ANZ	ZNZ	BKK	Bangkok	Thailand
OM-12 CLA	ZLA	GRU	Sao Paulo	Brazil
OM-13 AF	ZAF	DAR	Dar Es Salaam	Tanzania

Notes: As described in section 3.3, where a future market rather than a destination has been specified, the destination selected was selected to represent the average distance from Heathrow airport in that region.