Heathrow Airport Limited

Heathrow's North-West Runway

Carbon Footprint Assessment

26 June 2014

AMEC Environment & Infrastructure UK Limited

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Non-Technical Summary

This Carbon 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 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 Sustainability Appraisal Framework (SAF)[2] identifies a need for schemes to minimise the carbon emissions associated with construction and with the day to day ground operations associated with infrastructure.

In response to this requirement this report provides Heathrow's assessment of carbon emissions in 2030 and 2040, with and without the north-west runway, from aircraft movements on the ground and up to 3,000ft (the landing and take-off cycle), passenger and staff surface access to the airport, energy use, ground support vehicles and from the embodied carbon contained in new infrastructure and considered the significance of carbon associated with changes in land use. The assessment also provides details of the carbon mitigation and adaptation measures that have been adopted by our proposal.

The Airports Commission Appraisal Framework also identified a need for an assessment of the net change in carbon emissions at a national level through the addition of capacity, including the monetary valuation of those emissions. This needs to take into account not just the in-flight emissions from any one option for increased capacity, but the impact on other UK airports as well. It is therefore a task for the Commission and has not been addressed by this report. It is noted here that analysis already completed by the Airports Commission and reported

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

[2] Airports Commission (2014) Appraisal Framework. April 2014. Available at https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/300223/airports-commission-appraisal-framework.pdf

in the Interim Report[3] and the Committee on Climate Change[4] 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 report therefore presents:

- The legislative and policy context;
- The methodology used to calculate Heathrow's carbon footprint emissions;
- Heathrow baseline carbon emissions; and
- The carbon emissions for the development scenario in 2030 and 2040.

Heathrow's Carbon Footprint

In 2010 the carbon footprint of Heathrow was 2.2 Mt CO_2e. By 2030 in a "Business as Usual" scenario with 2 runways, 477,000 ATMs and 69.4 mppa, this would decrease to 1.4 Mt CO_2e. Developing a third runway at Heathrow would deliver a scheme in 2030 with 570,000 ATMs and 103.6 mppa, and 1.7 Mt CO_2e, which is projected to increase to 2.1 Mt CO_2e by 2040, with the increase in ATMs to 740,000 and 130.3 mppa.

Emissions from Ground Support Equipment and airside vehicles have been considered but the emissions from these sources are negligible compared with the other contributors to the carbon footprint and these have, therefore, not been considered further and do not appear in the carbon footprint totals.

Table NTS.1 summarises the Heathrow Carbon Footprint.

[3] Airports Commission: Interim Report, December 2013, https://www.gov.uk/government/publications/airports-commission-interim-report

[4] Meeting the UK Aviation target – options for reducing emissions to 2050, Committee on Climate Change, December 2009, http://www.theccc.org.uk/publication/meeting-the-uk-aviation-target-options-for-reducing-emissions-to-2050/

Table NTS.1 Summary of results, CO_2e emissions (Mt) from the Baseline and Development scenarios

Parameter	2010 2R (477,000 ATMs 69.4 mppa)	2030 2R (480,000 ATMs 75.9 mppa)	2030 3RNW (570,000 ATMs 103.6 mppa)	2040 3RNW (740,000 ATMs 130.3 mppa)
Heathrow Carbon Footprint				
LTO	1.2	0.9	1.1*	1.4
Travel to and from the airport	0.7	0.4	0.5	0.6
Energy	0.3	0.1	0.1	0.1
Total Carbon Footprint	2.2	1.4	1.7*	2.1

Notes: *Numbers differ from Chapter 5.7 following receipt of updated LTO emissions data

Embodied Carbon

Embodied carbon due to the construction of the third runway and associated infrastructure is estimated to be 3.6 Mt CO_2e.

Land Use Change

The mitigation strategy for the natural environment aims to create significant areas of high quality green space. The proposals are currently at a relatively high level so to calculate changes in land use at this point would be inappropriate. However, the change in carbon emissions due to land use is likely to be insignificant in carbon terms and has not been considered further.

Abbreviations

ACI	Airports Council International
APU	Auxiliary Power Units
ATMs	Air Transport Movements
CAA	Civil Aviation Authority
CCC	Committee on Climate Change
CEMP	Construction Environmental Management Plan
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
GHG	Greenhouse gases
GSE	Ground Support Equipment
GWP	Global Warming Potential
HS2	High Speed 2
ICAO	International Civil Aviation Organization
LTO	Landing and Take-Off cycle
LULUCF	Land Use, Land-Use Change and Forestry
mppa	Million passengers per annum
SAF	Sustainability Appraisal Framework
TTS	Track Transit System
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[5]. 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[5].

This report provides the technical assessment and details underlying the Carbon strategy presented in Volume 1 of HAL's submission to the Airports Commission[5]. Before describing the Airports Commission Sustainability Appraisal Framework (SAF) requirements in section 1.6, sections 1.1 to 1.2 define the greenhouse gases considered in this report; emissions sources particularly with respect to aircraft; and in section 1.3 the traded and non-traded emission sectors. 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 2030 and 2040. Conclusions are contained in section 6.

1.1 Greenhouse Gases

The term "carbon" is used to describe the six direct greenhouse gas (GHG) emissions under the Kyoto Protocol[6]. The six gases are:

- Carbon dioxide (CO_2);

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

[6] The United Nations Framework Convention on Climate Change and Kyoto protocol: https://unfccc.int/2860.php

- Methane (CH_4);
- Nitrous oxide (N_2O);
- Hydrofluorocarbons (HFCs) ;
- Perfluorocarbons (PFCs) ; and
- Sulphur hexafluoride (SF_6).

The emissions can be expressed in terms of the mass of each gas emitted or, to provide a combined total, emissions of non-CO_2 GHGs can be expressed as the amount of CO_2 that would have an equivalent global warming effect or global warming potential (GWP). When expressed in this way the carbon emissions are referred to as CO_2 equivalent, CO_2e.

1.2 Sources of Emissions

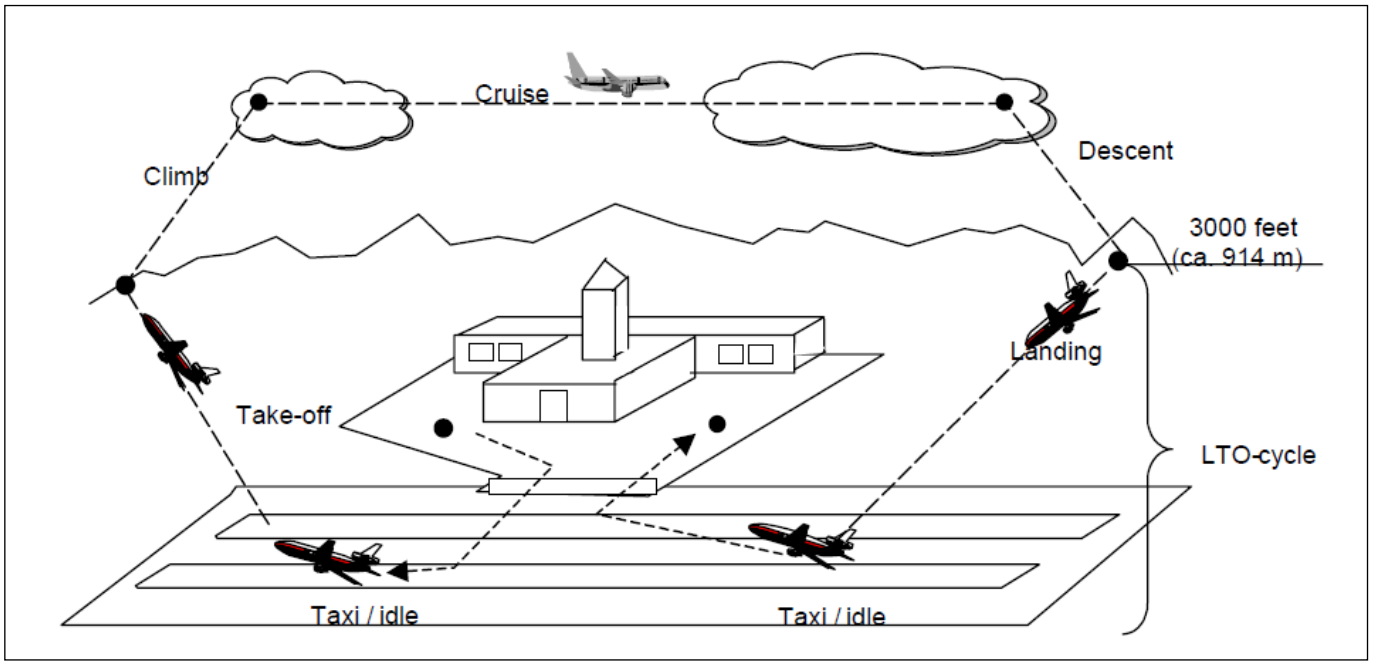
Changes in carbon emissions under different scenarios have been calculated for the following emission sources:

- Aircraft on the ground and in the air up to 3,000ft: the landing and take-off cycle (LTO) as defined below in **Figure 1.1**;
- Non-aviation transport of passengers and staff to and from Heathrow. This is referred to as "surface access";
- Operational energy use;
- Embodied carbon due to the construction of new facilities and surface access infrastructure; and
- Land use change due to development.

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.

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

Figure 1.1 Schematic of the Landing and Take-off Cycle (below 3,000ft)



1.3 Traded and Non-traded Emissions

The traded sector of emissions, relevant to this assessment report, 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;
- 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.

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

1.4 Heathrow's Objectives

The Airports Commission's Interim Report and the Committee on Climate Change 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 report deals with Heathrow's carbon footprint, that is, the carbon impacts of building and operating the three-runway airport.

This assessment therefore aims to identify measures that will minimise carbon emissions from:

- Aircraft on the ground and in the landing and take–off (LTO) cycle (below 3,000ft);
- Transport of passengers and staff to and from Heathrow; and
- The manufacture and transport of materials used to construct the airport – i.e. embodied carbon, and airport operation.

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].

The approach to minimising Heathrow's carbon footprint is detailed below.

1.5 Heathrow's Approach to Carbon Management

Heathrow has been measuring its carbon footprint since 2008. 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. Examples of initiatives that support the 'guide' principle include:

- Investing in energy-efficient rapid transport systems to take passengers from car parks to the terminal;
- Establishing the biggest car share scheme in Europe; and

[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

- Cutting the number of delivery vehicles to Heathrow by opening an efficient consolidation centre that eliminates unnecessary journeys.

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

- 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 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
- 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.

1.6 Airports Commission Requirements

The Airports Commission Sustainability Appraisal Framework (SAF) identifies a need for schemes to minimise the carbon emissions associated with construction and with the day to day ground operations associated with infrastructure.

In response to this requirement this report provides Heathrow's assessment of carbon emissions in 2030 and 2040, with and without the north west runway, from aircraft movements on the ground and up to 3,000ft (the landing and take-off cycle), passenger and staff surface access to the airport, energy use, ground support vehicles and from the embodied carbon contained in new infrastructure and has considered the significance of carbon associated with changes in land use. The assessment also provides details of the carbon mitigation and adaptation measures that have been adopted by our proposal.

The Airport Commissions Appraisal framework also identifies a need for an assessment of the net change in carbon emissions at a national level through the addition of capacity, including the monetary valuation of those emissions. This needs to take into account not just the in-flight emissions from any one option for increased capacity but also the impact on other UK airports and is therefore a task for the Commission and has not been attempted by this

[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.

report. It is noted here that analysis already completed by the Airports Commission and reported in the Interim Report[12] and the Committee on Climate Change[13] 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.

Table 1.1 shows how the source groups used in this report to calculate emissions map to the SAF categories and the relevant sections of this report.

Table 1.1 Relationship of Emissions Categories Required by the SAF with the Calculation Categories

SAF categories	Calculation categories used in this report	Relevant sections of this report
Increased airport capacity leading to a net change in air travel	Aircraft in the air and on the ground (LTO)	3.2
Departure and arrival route changes through altered flight operations	Aircraft in the air and on the ground (LTO)	3.2
Construction of new facilities and surface access infrastructure	Embodied carbon, Land use change	3.6, 3.7, 5.3
Airside ground movements and airport operations	Ground support equipment and operational vehicles at the airport	3.4
Changes in non-aviation transport patterns	Transport of passengers and staff to and from Heathrow (Surface access)	3.3
	Energy use	3.5*

Note: The strategy for reduction of operational energy use is described in more detail in the Technical Appendix to Chapter 5.8, a resource efficient Heathrow[9].

To address the SAF requirements, we have undertaken this analysis for the 2R scenarios in 2010, 2030 and 2040 and the 3RNW scenarios in 2030 and 2040. Carbon emissions have been calculated in accordance with HM Government's appraisal guidance produced by the Department for Energy and Climate Change (DECC).[14]

Carbon mitigation is built into the design of the proposed development and the effects of that mitigation are discussed in section 5.1.

[12] Airports Commission: Interim Report, December 2013, https://www.gov.uk/government/publications/airports-commission-interim-report

[13] Meeting the UK Aviation target – options for reducing emissions to 2050, Committee on Climate Change, December 2009, http://www.theccc.org.uk/publication/meeting-the-uk-aviation-target-options-for-reducing-emissions-to-2050/

[14] DECC Valuation of energy use and greenhouse gas (GHG) emissions, September 2013 https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/248603/2013_Main_Appraisal_Guidance_-_FINAL.pdf

2. Legislative and Policy Context

The Climate Change Act 2008[15] 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[16], 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[17] 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[18].

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

[16] 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

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

[18] UK DfT (2013) Aviation Forecasts, January 2013.

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 future scenarios for Heathrow that have been considered in this carbon footprint assessment. The scenarios assessed in this report are discussed below under the individual categorisation of emission sources.

Table 3.1 Scenarios

Year	Scenario	ATMs	Passenger numbers (mppa)	Number of employees
2010	2R	477,000	69.4	76,000
2030	2R	480,000	75.9	70,000
2030	3RNW	570,000	103.6	80,000
2040	2R	480,000	86.8	70,000
2040	3RNW	740,000	130.3	105,000

3.2 Aircraft in the LTO Cycle

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 that take place below 3,000 ft (914m) are referred to as the landing and take-off (LTO) cycle. CO_2 emissions from the LTO have been calculated on the detailed basis of fuel used, as part of the Air Quality Report recently provided to the Airports Commission, using fuel use factors contained in the ICAO database and future forecasts of aircraft fleet mix. LTO emissions include emissions from aircraft engines and the auxiliary power units (APU) on aircraft. Further details of the assumptions made in calculating fuel used in the LTO can be found in the Air Quality Assessment report.

3.3 Transport of passengers and staff to and from Heathrow

Road and rail emission factors for 2010 have been taken from the 2010 Guidelines to Defra/ DECC's GHG Conversion Factors for Company Reporting[19]. Factors for the improvement in fleet emissions between 2010 and the future year 2030 have been calculated from the DfT forecasts and are summarised in **Table 3.2**. For road traffic data factors were calculated from Figure 3.7 of the *Road Transport Forecasts 2011*[20]. Factors for rail were obtained from Figure 3.3 of the DfT's *Factsheets, UK transport greenhouse gas emissions.*[21]

Table 3.2 Factors Used to Calculate CO_2 Emissions from Transport in 2030

Years	Mode	Factor
2010/2030	Car	0.5729
2010/2030	Light van	0.7010
2010/2030	HGV	0.9184
2010/2030	Rail	0.7547

The data supplied by HAL on the modal split and kilometres travelled by public and private transport by passengers and employees are given in **Table 3.3** and **Table 3.4** respectively. Whilst there will be no additional trips in 2030 and 2040 due to the third runway, the passenger vehicle kms will increase as passengers will, on average, travel further to the hub airport. Over the same period staff trips are being reduced in length.

[19] 2010 Guidelines to Defra / DECC's GHG Conversion Factors for Company Reporting, October 2010 http://archive.defra.gov.uk/environment/business/reporting/pdf/101006-guidelines-ghg-conversion-factors.xls

[20] Department for Transport (2012) Road Transport Forecasts 2011, Results from the Department for Transport's National Transport Model, January 2012, http://assets.dft.gov.uk/publications/road-transport-forecasts-2011/road-transport-forecasts-2011-results.pdf

[21] Department for Transport, Factsheets, UK transport greenhouse gas emissions, https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/3085/41.pdf, accessed 7 May 2013

Table 3.3 Annual Air Passenger Surface Access (million kms)

Mode	2030 2R	2030 3RNW	2040 2R	2040 3RNW
Underground	327	563	327	636
Bus/Coach	771	1,151	771	1,525
Heathrow Express	178	449	178	807
Crossrail	243	377	243	695
Standard Rail	515	280	515	349
Air Transfer	24	29	24	36
Charter Coach	122	178	122	231
BR Coach	10	24	10	29
Sub-total	**2,180**	**3,052**	**2,180**	**4,309**
Taxi	568	766	568	843
Park-and-Fly	660	881	660	1,055
Kiss-and-Fly	801	953	801	1,142
Sub-total	**2,030**	**2,599**	**2,030**	**3,039**
Grand Total	**4,210**	**5,651**	**4,210**	**7,348**

Table 3.4 Annual Employee Surface Access (million kms)

Mode	2030 2R	2030 3RNW	2040 2R	2040 3RNW
Rail	96	164	96	264
Bus/Coach	100	173	100	278
Sub-total	**196**	**337**	**196**	**542**
Private Car	357	306	357	211
Sub-total	**357**	**306**	**357**	**211**
Grand Total	**553**	**643**	**553**	**753**

3.4 Ground Support Equipment

Emissions from Ground Support Equipment and airside vehicles have been considered but the emissions from these sources are negligible compared with the other contributors to the carbon footprint and these have, therefore, not been considered further and do not appear in the carbon footprint totals.

3.5 Energy

CO_2 emissions due to energy are detailed in the Technical Appendix to Chapter 5.8, a resource efficient Heathrow[9].

3.6 Embodied Carbon

Embodied carbon refers to the emissions that occur during the manufacture and transport of construction materials and components, as well as the construction process itself. These emissions are historical emissions from the material's production processes plus the current emissions due to transport to site, travel of construction labour and energy used during construction.

Embodied carbon emissions have been calculated by combining appropriate emission factors with activity data. Data relating to the proposed developments were obtained from HAL; however as these data were not from a detailed design they did not include in the majority of cases specific quantities of materials to be used during construction. For this reason, in some instances it was necessary to make assumptions in order to estimate the embodied carbon associated with the development. Once information as to the quantities of construction materials to be used becomes available it will be possible to calculate a more specific embodied carbon footprint based on a "bottom-up" approach. This approach will combine quantities of materials used with material specific emission factors, and has the potential to make use of existing carbon calculation tools, such as the Carbon Calculator for Construction Projects[22]. Emissions due to labour, transport and energy used have been estimated in most cases as a proportion of the embodied carbon.

The factors and assumptions used in this assessment used are shown in **Table A.1** in **Appendix A**. **Table A.2** gives the activity data e.g. km of tunnel, gross floor area.

3.7 Land Use Change

The mitigation strategy for the natural environment aims to create significant areas of high quality green space. The proposals are currently at a relatively high level so to calculate changes in land use at this point would be inappropriate. However, the change in carbon emissions due to land use is likely to be insignificant in carbon terms, and has not been considered further.

[22] Environment Agency (2012) Carbon calculator for construction projects (online). Available at: https://www.gov.uk/government/publications/carbon-calculator-for-construction-projects

4. Baseline and Future Base Cases

4.1 Heathrow's Carbon Footprint

The carbon footprint in the baseline year of 2010 and the future two runway ("do minimum") scenarios are given in **Table 4.1**. The carbon emissions are forecast to decrease between 2010 and 2030 from 2.2 Mt CO_2e to 1.4 Mt CO_2e. That overall reduction is due to a decrease in emissions due to LTO, surface access and energy use. Taking a conservative approach the emissions are forecast to remain the same in 2040. Only the travel to and from the airport falls into the non-traded sector of emissions, the other two sectors are traded.

Table 4.1 Heathrow's Carbon Footprint - Baseline and Base Case (Mt CO_2e)

Group	2010 2R	2030 2R	2040 2R
LTO	1.2	0.9	0.9
Travel to and from the airport	0.7	0.4	0.4
Energy	0.3	0.1	0.1
Total	**2.2**	**1.4**	**1.4**

4.1.1 Embodied Carbon

With approximately 60% of the proposed three-runway airport infrastructure already in place, and with Heathrow already supporting just under 480,000 ATMs annually, much of the embodied carbon of our future masterplan is already in place. Our experience also tells us that there is significant scope to recycle and reuse materials for buildings that will be changed or lost as the masterplan is developed. For example, when HAL demolished the old Terminal 2 building, 99% of the building by weight was recycled.

5. Future Development Carbon Emissions

5.1 Mitigation Measures

The following measures are part of HAL's Carbon Mitigation Strategy.

5.1.1 Aircraft

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 LTO cycle and hence reduce emissions.

Heathrow also has a long-standing policy position on the need to include aviation in a global emissions trading scheme, believing 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 tackle net emissions.

HAL has been active for more that 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 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.

5.1.2 Surface Access

Heathrow is already served by a choice of well-established public transport and the strategic highway network. As described in the Airport Surface Access Strategy, HAL's public transport-led strategy will bring almost 2 million more people within a one-hour public transport journey of the airport. Taken together, HAL's surface access strategy aims to increase the public transport mode share from today, where just over 40% of passengers use public transport, to over 50% by 2030 and over 55% by 2040. HAL will also continue to reduce the number of staff driving to work, through the continued work of the Heathrow Commuter Team and reductions in staff car parking.

5.1.3 Energy Use

These measures are listed in the 'A Resource Efficient Heathrow' chapter of the Heathrow masterplan[9].

5.1.4 Construction

To minimise embodied carbon, the Construction Environmental Management Plan (CEMP) will include measures to reduce carbon emissions during construction. These measures are expected to include:

- Re-use and use of recycled and/or low carbon materials;
- Maximising the use of locally sourced materials and minimising transport distance; and
- Encouraging the use of public transport for staff and the use of sustainable transport methods – such as rail transport where feasible – for construction materials and plant.

5.2 Heathrow's Future Carbon Footprint

Table 5.1 compares the Heathrow carbon footprint of the 3RNW Project in 2030 and 2040 with 570,000 ATMs and 103.6 mppa, and 740,000 ATMs and 130.3 mppa respectively.

Table 5.1 Heathrow's Carbon Footprint, 3RNW Project (Mt CO_2e)

Source	2030 3RNW (570,000 ATMs 103.6 mppa)	2040 3RNW (740,000 ATMs 130.3 mppa)
LTO	1.1	1.4
Travel to and from the airport	0.5	0.6
Energy	0.1	0.1
Total Carbon Footprint	**1.7**	**2.1**

5.3 Embodied Carbon

Embodied carbon emissions associated with the proposed developments are given in **Table 5.2**. Values are provided as Mt CO_2e. The estimated emission resulting from embodied carbon within the 3RNW development is 3.6 Mt CO_2e. This is a "one-off" figure rather than an annual figure. The quantities of the different materials to be used for the development, including on-airport and off-airport infrastructure were derived from a master "Bill of Quantities" developed jointly by HAL, Mott MacDonald and EC Harris and are given in **Table A.2** of **Appendix A**.

Airport infrastructure, specifically the construction of terminals and satellites, is the largest contributor to embodied carbon emissions, responsible for 63.5%. This is to be expected as it includes the embodied carbon in the construction of the new terminals. Emissions due to construction of the Baggage and Track Transit System (TTS), which includes the construction of tunnels, is the second largest contributor to total embodied emissions, contributing 16.1%, whilst the Other category, including plant, labour and commuting emissions are also a significant contributor, accounting for 10.9%.

The factor used in this assessment for tunnelling assumes that embodied carbon from tunnel construction was equal to that of High Speed 2 (HS2) (approximately 40 kt CO_2/km) which accounted for embodied carbon from the construction of tunnels, portals and dive-unders, as well as from a tunnel boring machine and its associated labour and plant emissions. As a comparator, Thames Water (2013) state embodied emissions of approximately 33 kt CO_2/km associated with the materials, worksite activities and logistics of constructing the Thames Tideway sewer. Sewer tunnels are, however, simpler in form and therefore embody less carbon emissions per kilometre.

Table 5.2 CO_2e Emissions (Mt) from Embodied Carbon

Development category	Embodied Carbon (Mt CO_2e)	Percentage of total embodied carbon (%)
Motorways	0.033	0.9
Airport infrastructure	2.268	63.5
Baggage and TTS	0.576	16.1
Airfield	0.295	8.3
Fuel Farms	0.005	0.1
Landside Infrastructure	0.006	0.2
Other (plant, labour and commuting)	0.388	10.9
TOTAL	**3.569**	**100.0**

6. Conclusions

This report presents the work carried out in response to the Airports Commission SAF Appraisal module for Carbon. Carbon emissions have been calculated and compared with the "do minimum" scenarios.

Table 6.1 summarises the carbon emissions that have been calculated.

Table 6.1 Summary of results, CO_2e emissions (Mt) from the Baseline and Development scenarios

Parameter	2010 2R (477,000 ATMs 69.4 mppa)	2030 2R (480,000 ATMs 75.9 mppa)	2030 3RNW (570,000 ATMs 103.6 mppa)	2040 3RNW (740,000 ATMs 130.3 mppa)
Heathrow Carbon Footprint				
LTO	1.2	0.9	1.1*	1.4
Travel to and from the airport	0.7	0.4	0.5	0.6
Energy	0.3	0.1	0.1	0.1
Total Carbon Footprint	2.2	1.4	1.7*	2.1

Notes: *Numbers differ from Chapter 5.7 following receipt of updated LTO emissions data

Embodied Carbon

Embodied carbon due to the construction of the third runway and associated infrastructure is estimated to be 3.6 Mt CO_2e.

Land Use Change

The mitigation strategy for the natural environment aims to create significant areas of high quality green space. The proposals are currently at a relatively high level so to calculate changes in land use at this point would be inappropriate. However, the change in carbon emissions due to land use is likely to be insignificant in carbon terms and has not been considered further.

Appendix A
Detailed Input Data – Embodied Carbon

Table A.1 Assumptions and Factors used in the Embodied Carbon Footprint Calculation

Development Activity	Assumptions and Emission Factors used
Motorways : M25 Diversions	
Cut and cover tunnel construction	40,055 tCO_{2e} per km of tunnel [a]
New M25 construction	That the new M25 would have 8 lanes 325 tCO_2 per lane km [b]
Motorways: M25 / T5 Junction Refurbishment	
Allowance for alterations and road widening	It was assumed that the width of the road to be altered was equal to three lanes due to the addition of pavement 300 tCO_2 per lane km [b]
Airport Infrastructure and buildings: Terminals and satellites	
T6 - New terminal	4 tCO_2 per m^2 of over ground floor space construction [c]
Basement	4 tCO_2 per m^2 of over ground floor space construction [c]
New Satellite. Above ground construction	4 tCO_2 per m^2 of over ground floor space construction [c]
New Satellite. Basement construction	4 tCO_2 per m^2 of over ground floor space construction [c]
EBS Basement construction	4 tCO_2 per m^2 of over ground floor space construction [c]
Airport Infrastructure and Buildings: Western Campus	
Additional basements for new TTS stations to T5A, B & C	4 tCO_2 per m^2 of over ground floor space construction [c]
Baggage and TTS: Civils	
Baggage Tunnels (Bored) T6A - T5A	40,055 tCO_{2e} per km[a]
Baggage Tunnels (New Cut & Cover) T6A to T6B	40,055 tCO_{2e} per km[a]
Safeguard for T6C satellite construction of cut and cover tunnel and top slab only	40,055 tCO_{2e} per km[a]
Tunnel Construction (Bored)	40,055 tCO_{2e} per km [a]
Tunnel Construction (Cut & Cover)	40,055 tCO_{2e} per km [a]
Safeguard for T6C satellite construction of cut and cover tunnel and top slab only	40,055 tCO_{2e} per km [a]
Baggage and TTS: TTS maintenance base	
Maintenance Base	It was assumed that the embodied carbon per m^2 of over ground floor space is equal to that of the construction of T6 4 tCO_2 per square meter of over ground floor space [c]

Table A.1 (Continued) Assumptions and Factors used in the Embodied Carbon Footprint Calculation

Development Activity	Assumptions and Emission Factors used
Baggage and TTS: Runways and parallel taxiways	
New northern runway	Based on the knowledge that the new runways would have layers of asphalt (225mm), pavement quality concrete (450mm), lean mix concrete (150mm) and sub-base (Type 1, 200mm), embodied carbon was calculated using the below factors: 0.110 $kgCO_2$ per kilogram of concrete [d] 0.004 $kgCO_2$ per kilogram of aggregate [d] 0.066 $kgCO_{2e}$ per kilogram of asphalt [e]
New northern runway shoulders (2 x 15m)	It has been assumed that the embodied carbon is equal to that of 66% of the embodied carbon associated with the northern runway construction; 66% was chosen for the reason that while the runway shoulders need to be hardwearing, they are likely to be less hardwearing than the runway and hence have less embodied carbon 0.124 tCO_2 per square meter [f]
New Taxiway Network	It has been assumed that the embodied carbon is equal to that of 50% of the embodied carbon associated with the northern runway construction; 50% was chosen for the reason that the taxiway network needs to be less hardwearing than the runway 0.094 tCO_2 per square meter [f]
New taxiway shoulders	It has been assumed that the embodied carbon is equal to that of 50% of the embodied carbon associated with the northern runway construction; 50% was chosen for the reason that the taxiway shoulder needs to be less hardwearing than the runway 0.094 tCO_2 per square meter [f]
Baggage and TTS: Stands and apron	
Stands / Apron to new T6 Terminal	It has been assumed that the embodied carbon is equal to that of 50% of the embodied carbon associated with the northern runway construction; 50% was chosen for the reason that the stands / apron to the new T6 need to be less hardwearing than the runway 0.094 tCO_2 per square meter [f]
Baggage and TTS: Contact stands to new satellites	
Stands / apron to new northern satellite	It has been assumed that the embodied carbon is equal to that of 50% of the embodied carbon associated with the northern runway construction; 50% was chosen for the reason that the stands / apron to the new northern satellite need to be less hardwearing than the runway 0.094 tCO_2 per square meter [f]
Baggage and TTS: Remote stands to new areas	
Remote stands	It has been assumed that the embodied carbon is equal to that of 50% of the embodied carbon associated with the northern runway construction; 50% was chosen for the reason that the remote stands to new areas need to be less hardwearing than the runway 0.094 tCO_2 per square meter [f]
Baggage and TTS: Airside road tunnels	
Tunnel (Bored)	40,055 tCO2e per km [a]
Tunnel (C+C)	40,055 tCO2e per km [a]
Reinstatement of surface and taxiway above tunnels	It has been assumed that the embodied carbon is equal to that of 66% of the embodied carbon associated with the northern runway construction; 66% was chosen for the reason that while the surface need to be hardwearing, they are likely to be less hardwearing than the runway and hence have less embodied carbon 0.124 tCO_2 per square meter [f]

Table A.1 (continued) Assumptions and Factors used in the Embodied Carbon Footprint Calculation

Development Activity	Assumptions and Emission Factors used
Baggage and TTS: Offices	
Office buildings - assumed 30% of total footprint. GFA assumed to be 3 x footprint. Refer MM documents 3R NW LUP areas	452 $kgCO_{2e}$ per square meter of office building [g]
Baggage and TTS: Catering	
Catering buildings - assumed 30% of total footprint.	It was assumed that the embodied carbon would be equal to that of a secondary school, which is considered to be similar 309 $kgCO_{2e}$ per m^2 of office building [g]
Baggage and TTS: Fuel Farms	
New fuel main trunk runs to stands	It was assumed that the embodied carbon would be equal to that of a minor urban road, three lanes wide, which is considered to be of similar magnitude 300 tCO_2 per lane km [b]
Landside infrastructure: Surface Car Parks (Passenger)	
T5/T6 Business - Surface car park at West end of existing Northern Runway (at Grade)	In the absence of information relating to the space required for one car parking space, (plus room to manoeuvre, it was assumed that each car parking space would require 6 m^2, and the embodied carbon would equal that of a warehouse (frame and upper floors) due to similarities in built form 32 $kgCO_{2e}$ per square meter [g]
Basement access to grade car park (G-1)	It was assumed that the embodied carbon would equal that of a warehouse (frame and upper floors) due to the similarities in built form 32 $kgCO_{2e}$ per square meter [g]
Decked Multi Storey Car Parks; Passenger (long stay)	It was assumed that the embodied carbon would equal that of a warehouse (frame and upper floors) due to the similarities in built form 32 $kgCO_{2e}$ per square meter [g]
Terminal Multi Storey Car Parks (short stay)	It was assumed that the embodied carbon would equal that of a warehouse (frame and upper floors) due to similarities in built form 32 $kgCO_{2e}$ per square meter [g]
Other: Plant, labour and commuting	
Additional emissions from plant (energy use), labour and commuting	It was assumed that these were 15% of the total embodied carbon, excluding the below activities, whose factors already include plant and labour emissions: Emissions associated with tunnelling Emissions associated with the construction of office and catering buildings

Notes:

[a] Derived from data taken from: High Speed Two (HS2) (2013) London-West Midlands Statement: Volume 5: Technical Appendices (online). Available at: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/260116/HS2_London_to_West_Midlands_EIA_Scope_Methodology_Report_revised_0.pdf

[b] Transport Scotland (2009) STAG Technical Database (online). Available at: http://www.transportscotland.gov.uk/stag/j302931-07.htm

[c] Derived from data taken from: Heathrow Sustainability (n.d.) Embodied Carbon in Construction Materials Used on T2A and T2B

[d] SimaPro UK (2013) SimaPro 7.3.3 software

[e] University of Bath (2011) Inventory of Carbon and Energy (ICE).

[f] Derived as a percentage of the factor calculated for the creation of the new northern runway

[g] Sansom and Pope (2012) A comparative embodied carbon assessment of commercial buildings. The Structural Engineer.

Table A.2 Activity Data Used for Calculation of Embodied Carbon

Development Activity	Activity Data
Motorways : M25 Diversions	
Cut and cover tunnel construction	616 m
New M25 construction	2,956 m
Motorways: M25 / T5 Junction Refurbishment	
Allowance for alterations and road widening	800 m
Airport Infrastructure and buildings: Terminals and satellites	
T6 - New terminal	282,114 m^2
Basement	70,000 m^2
New Satellite. Above ground construction	132,210 m^2
New Satellite. Basement construction	66,105 m^2
EBS Basement construction	30,000 m^2
Airport Infrastructure and Buildings: Western Campus	
Additional basements for new TTS stations to T5A, B & C	62,205 m^2
Baggage and TTS: Civils	
Baggage Tunnels (Bored) T6A - T5A	880 m
Baggage Tunnels (New Cut & Cover) T6A to T6B	1,722 m
Safeguard for T6C satellite construction of cut and cover tunnel and top slab only	770 m
Tunnel Construction (Bored)	3,372 m
Tunnel Construction (Cut & Cover)	3,444 m
Safeguard for T6C satellite construction of cut and cover tunnel and top slab only	1,540 m
Baggage and TTS: TTS maintenance base	
Maintenance Base	30,000 m^2
Airfield: Runways and parallel taxiways	
New northern runway	210,000 m^2
New northern runway shoulders (2 x 15m)	105,000 m^2
New Taxiway Network	485,603 m^2
New taxiway shoulders	679,844 m^2
Airfield: Stands and apron	
Stands / Apron to new T6 Terminal	30,000 m^2
Airfield: Contact stands to new satellites	

Table A.2 (Continued) Activity Data Used for Calculation of Embodied Carbon

Development Activity	Activity Data
Stands / apron to new northern satellite	212,045 m^2
Airfield: Remote stands to new areas	
Remote stands	139,429 m^2
Airfield: Airside road tunnels	
Tunnel (Bored)	1,300 m
Tunnel (C+C)	1,100 m
Reinstatement of surface and taxiway above tunnels	1,100 m
Fuel Farms	
New fuel main trunk runs to stands	5,000 m
Landside infrastructure for car parking	
Car parks	175,660 m^2