ESTIMATING EMISSIONS FROM HEATHROW AIRPORTS

Summary

Base Year: 2008

Because of lack of recent, representative and reliable activity datasets for the 2008 base year, emission estimates for NO_X, PM_{10}, CO, CO_2, SO_2, benzene and 1,3-butadiene from the 2002 Heathrow Emissions Inventory (HEI), which were originally provided by AEA in combination with recent aircraft movements statistics from DfT[12], were used. These emission estimates for the base year 2008 were spatially analysed and integrated into the LAEI 2008. Emissions from Heathrow's road traffic were excluded from the HEI dataset used to compile the LAEI 2008 in order to avoid double counting as these were already estimated under the Road Transport sector of the LAEI 2008.

Projection Years: 2011 and 2015

AEA provided projected (2010) emission estimates for NO_X, PM_{10}, CO, CO_2, SO_2, benzene and 1,3-butadiene from the 2010 Heathrow Emissions Inventory, which were then spatially analysed and integrated into the LAEI 2008. Again, emissions from Heathrow's road traffic were also excluded from the HEI dataset used in compiling the LAEI 2008.

Because of lack of recent, representative and reliable activity datasets, projection of atmospheric emissions from Heathrow airport to 2010 and 2015 were not undertaken; instead projections of atmospheric emissions from Heathrow airport to 2011 and 2015 were basically assumed to be the same as those in the 2010 Heathrow Emissions Inventory (same as the 2010 projection in the LAEI 2006).

2008 emission estimation methodology: (Same as the LAEI 2006 methodology)

Base Year

The trends in aircrafts movement data from DfT statistics[1] spreadsheet for "Aircraft Movements 1998 – 2008" at Heathrow Airport were analysed. It was calculated that there was 0.6% increase between 2004 and 2008 in the aircraft movements at Heathrow Airport. This % increase was used to upscale the original datasets.

AEA Technology provided the entire emission estimates for NO_X, PM_{10}, CO, CO_2, SO_2, benzene and 1,3-butadiene from the 2002 Heathrow Emissions Inventory. The methodologies for the 2002 Heathrow Emissions Inventory are commercially restricted documents (i.e., *Heathrow Emission inventory 2003: Part 1 – A report produced for BAA Heathrow; BY Underwood, C T Walker and M J Pierce. Netcen/AEAT/ENV/R/1657/Issue 4; August 2004* and *Heathrow Emission inventory 2003: Part 2 – A report produced for BAA Heathrow; BY Underwood, C T Walker and M J Pierce. Netcen/AEAT/ENV/R/1728/Issue 1; November 2004*). Therefore only the executive summaries are provided in this document.

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[1] http://www.dft.gov.uk/pgr/aviation/airports

The report describes the compilation of an inventory of atmospheric emissions from London Heathrow airport (LHR) for the base year 2002. The report describes the methodologies and datasets used to compile an inventory of the pollutants NO_X (nitrogen oxides) and PM_{10} (particulate matter of aerodynamic diameter less than 10 microns), CO (carbon monoxide), CO_2 (carbon dioxide), SO_2 (sulphur dioxide), benzene and 1,3-butadiene.

The inventory includes emissions from the following source categories:

- Aircraft in the landing and take-off (LTO) flight phases up to 1,000m, including Auxiliary Power Unit (APU) emissions and emissions from engine testing;
- Airside vehicles/plant;
- Road vehicles on airport landside roads and on the road network around the airport;
- Car parks and taxi queues;
- Airport heating plant; and
- Fire-training ground.

For $PM_{10,}$ the inventory also includes fugitive emissions from brake and tyre wear (for aircraft and road-vehicles).

Aircraft emissions are included in the inventory for the LTO flight phases up to 1,000m height, but the contribution from aircraft on the ground is separately identified. Road vehicle emissions are included for a road network within a 12km x 9km rectangle enclosing the airport. This choice relates to the modelling study presented in a separate report and allows a measure of comparability with the emissions presented previously on the near-Heathrow network.

One of the principal functions of the inventory is to provide essential inputs to a dispersion modelling study that identifies the airport contribution to the ground-level concentrations of key pollutants around the airport. Thus, besides quantifying total annual emissions, this report specifies the spatial distribution of the emissions on the horizontal plane.

For those source categories included in the 2000 inventory, the methodology for the 2002 inventory is largely unchanged from that used for 2000, but the following differences can be noted:

(a) the methodology for taking account of reduced-thrust aircraft take-off has been revised, particularly to refine assumptions that are now judged to be over-conservative; and

(b) the classification of vehicles as road or off-road vehicles in the airside-vehicle emissions methodology has been updated on the basis of more detailed information.

The estimate of total ground-level aircraft NO_x emissions is 9% lower for 2002 than it was for 2000, principally as a result of changes to the reduced-thrust methodology.

There is about 3% reduction in emissions per movement for those flight phases unaffected by the reduced-thrust changes, reflecting evolution in the aircraft fleet between 2000 and 2002. The corresponding change in emissions per passenger for this component of the inventory is smaller (a decrease of 1.7%). The estimate of total aircraft PM_{10} emissions per movement has fallen by 3%, principally reflecting the evolution of the aircraft fleet.
For NO_x and PM_{10}, aircraft provide the dominant contribution to ground-level airport-related emissions. The estimate for ground-level aircraft NO_x (PM_{10}) emissions is 7.5 (4.5) times larger than the estimate for airside vehicle emissions and 2.0 (2.1) times larger than the estimate for landside (airport-related) road vehicle emissions on the designated network. For NO_x, take-off roll is the LTO mode giving the largest contribution to ground level emissions, whereas for PM_{10} landing is the flight phase generating the largest fraction of total ground level aircraft emissions, as a result of current estimates of the contribution from brake and tyre wear.

The estimate of total NO_x emissions from airside vehicles/plant for 2002 is similar to that for 2000. The similarity in the total masks a significant change in the relative contributions from off-road and road vehicles due to extensive re-classification of vehicles on the basis of more detailed data. However, typical NO_x emission factors (in g/kg fuel) for road and off-road vehicles are not very different for the current fleet. The estimate of total PM_{10} emissions from airside vehicles/plant for 2002 is 38% smaller than that for 2000 principally as a result of the vehicle re-classification.

For ground-level airport-related emissions, landside road vehicles are the source category giving the second largest NO_x and PM_{10} contribution after aircraft: within this category, airport-related emissions on the designated network give the dominant contribution. For this component, the contribution from Heavy Goods Vehicles (HGVs) is larger than that from Light Duty Vehicles (LDVs) for both NO_x and PM_{10}, but there may be some overestimation of the HGV traffic fraction as a result of specific assumptions in the traffic modelling, which would in turn lead to an overestimation of the total emissions from road vehicles on the network.

For 2002, the estimated NO_x (PM_{10}) emissions from non-airport traffic on the designated network are 3.0 (3.2) times higher than the estimated NO_x (PM_{10}) emissions from airport related traffic. For the non-airport traffic, the contribution to annual emissions from HGVs is comparable to that from LDVs for NO_x and less than that from LDVs for PM_{10}.

Compared to the values in the 1998 inventory, estimated airport-related NO_x (PM_{10}) emissions on the network have fallen by 9% (30%), whereas estimated non-airport emissions have fallen by 41% (53%), although the networks used are not exactly the same. The smaller decrease for the airport contribution indicates a faster rate of growth of airport-related traffic compared to non-airport traffic between 1998 and 2002.

The 2002 emissions from heating plant do not correspond to quite the same list of plant as in the 2000 inventory, although the differences relate to minor contributions to the total. Using a common list of plant in the two years, the NO_x emissions have fallen by 9% from 2000 to 2002 for a 5% fall in fuel energy input. Similarly, for the common list of plant, PM_{10} emissions have fallen by 3% for the 5% fall in fuel energy input. The emissions decreases are not exactly pro rata with the fuel energy decrease because emission factors for different types of plant are different. Heating plants are not expected to make a major contribution to ground-level annual-mean concentrations beyond the airport perimeter.

In terms of recommendations for operational data improvements, more detailed information on reduced-thrust operation for airlines other than British Airways would be beneficial and also statistical information on reverse-thrust usage on landing for the whole LHR fleet. Similarly, more information on the variables influencing APU running times may be beneficial. For airside vehicle emissions, the recommendations made in the 2000 inventory report regarding fuel usage surveys or plant duty-cycle surveys are still relevant. The available activity data for airside vehicles/plant still do not allow a robust assessment of associated emissions, so changes from one inventory update to the next continue to be dominated by changes to the methodology, as the assumptions used to fill gaps in the activity data are gradually refined.

In relation to emission factors, the key uncertainties relate to aircraft PM_{10} emission factors (exhaust and fugitive) and emission factors for off-road/specialist airside vehicles/plant. Additional information is also required on the emissions performance of in-service aircraft engines compared to the factors in the ICAO databank.

Projection Years

AEA Technology provided the entire emission estimates for NO_X, PM_{10}, CO, CO_2, SO_2, benzene and 1,3-butadiene from the Heathrow Emissions Inventory 2010. The methodologies for the Heathrow Emissions Inventory 2010 are commercially restricted documents (i.e., *Heathrow 2010 Baseline Emission Inventory: Part 1 – A report produced for BAA Heathrow; BY Underwood, C T Walker and M J Pierce. Netcen/AEAT/ENV/R/1660/ Issue 3, August 2004* and *Heathrow 2010 Baseline Emission Inventory: Part 2 – A report produced for BAA Heathrow; BY Underwood, C T Walker and M J Pierce. Netcen/AEAT/ENV/R/1729/ Issue 1, November 2004*). Therefore only the executive summaries have been provided below.

The report describes the methodology and data used to forecast the inventory of atmospheric emissions from London Heathrow airport (LHR) in the year 2010[2]. This is an important year from an air quality perspective, in that 1 January 2010 marks the date by which agreed European Union (EU) limit values for NO_2 concentration must be met in Member States. It is also the specified date by which the EU Stage 2 (indicative) limit values for particulate matter are to be met.

The recent White Paper on the future of air transport in the UK supports a third runway at Heathrow in the 2015-2020 period provided the Government is confident that compliance with mandatory air quality limits can be maintained. Thus, there is significant stakeholder interest in forecasting the air quality situation in residential areas around the airport in 2010. The inventory presented in this report is intended to serve as the basis for calculating the 'baseline' air quality in 2010, i.e., the air quality under the assumption that the airport evolves without forcing measures introduced

[2] The inventory is based on the most current information on 2010 available at the end of 2003.

specifically to mitigate air quality impacts.

The reports describe the methodology and data used to compile an inventory of the pollutants NO_X (nitrogen oxides) and PM_{10} (particulate matter of aerodynamic diameter less than 10 microns), CO (carbon monoxide), CO_2 (carbon dioxide), SO_2 (sulphur dioxide), benzene and 1,3-butadiene.

The inventory includes emissions from the following source categories:
(a) Aircraft in the Landing and Take-Off (LTO) flight phases, including Auxiliary Power Unit (APU) emissions and emissions from engine testing;
(b) Airside vehicles/plant;
(c) Road vehicles on airport landside roads and on the road network around the airport;
(d) Car parks and taxi queues;
(e) Airport heating plant; and
(f) Fire-training ground.

For PM_{10}, the inventory also includes fugitive emissions from brake and tyre wear (for aircraft and road-vehicles), but excludes any contribution from construction activities.

Aircraft emissions are included in the inventory for the LTO flight phases up to 1,000m height, but the contribution from aircraft on the ground is separately identified. Road-vehicle emissions are included for a road network within a 12km x 9km rectangle enclosing the airport. This choice allows comparability with the emissions presented for the 2002 inventory. For heating plant, emissions associated only with on-airport energy requirements (including those for T5) are included in the inventory.

The methodology for estimating emissions is largely the same as that used for the 2002 inventory, although for aircraft it was modified to reflect the lower level of detail available in the forecast aircraft movement data compared with that for current movement data. For aircraft times-in-mode, the assumption was made that at the highest level of detail available, the time-in-mode data used for the 2002 inventory are still applicable in 2010. Of course, this may still lead to differences in average times-in-mode, for example as a result of fleet evolution and differences in the pattern of terminal usage. Similarly, the average take-off thrust settings for specific aircraft types were assumed to be the same in 2010 as in current operations.

For road traffic emissions, 2010 baseline forecast data were provided by W S Atkins on behalf of BAA Heathrow for a similar network to that used for the 2002 inventory but taking account of anticipated network developments associated with T5. The airport-related component of the traffic was based on passenger and mode share forecasts consistent with those used in the aircraft movement predictions and with the data provided on car parking on the airport. Airside vehicle activity on the airport was assumed to grow in proportion to total passenger throughput. For the baseline estimate, the relative age distribution of the airside vehicle fleet was assumed to be the same as in 2002 apart from constraints on maximum age imposed by Operational Safety Instructions. Heat energy use on the airport was assumed to grow to meet the needs of the T5 development; in the baseline it was assumed that conventional boilers would meet these needs.

The number of movements is predicted to increase by 4% from 466,554 in 2002 to a total of 485,500 movements in 2010 (including non-ATMs[3]), with a forecast 28% increase in passengers, from 63.0mppa in 2002 to 80.9mppa in 2010. The baseline aircraft fleet is expected to evolve such that the B737 (all series) will account for a much smaller fraction of the movements in 2010, with the A320/A321 and the B777 accounting for a much larger fraction than in 2002. In the baseline 2010 fleet, the future A380 is expected to account for around 4% of the total movements.

For both NO_x and PM_{10}, ground-level aircraft emissions represent the largest contribution to airport-related ground-level emissions. For NO_x, this contribution is 13.6 times larger than the contribution from airside vehicles/plant and 3.0 times larger than the contribution from airport-related traffic on the designated road network. For PM_{10}, the estimate of ground-level aircraft emissions is 8.2 times that for airside vehicles/plant and 2.6 times that from airport-related road traffic on the designated road network.

For ground-level aircraft NO_x emissions, take-off roll gives the largest contribution, accounting for nearly half of the total, in spite of the fact that roll times are substantially shorter than taxiing times. This results from the relatively high thrust setting on take-off, even after taking account of reduced-thrust take-off. For ground-level aircraft PM_{10} emissions, brake and tyre wear is the dominant contributor, accounting for around two thirds of the ground-level PM_{10} emissions from aircraft. However, there are large uncertainties associated with this contribution, which results from generalisation from a single item of data.

The forecast total aircraft NO_x emissions in 2010 are 31% higher than in 2002. This is a larger fractional increase than the fractional increase in the number of movements, as would be expected given that the average size of aircraft increases as the airport develops. It is also a larger fractional increase than the fractional increase in the number of passengers, reflecting a trend in the NO_x performance (in the LTO flight phases) of the current generation of large jet engines. Engine designs are now entering the fleet that are aimed at addressing this trend.

On the other hand, ground-level aircraft PM_{10} emissions are predicted to be almost the same in 2010 as in 2002, despite an increase in the numbers of movements and passengers. This results from a cancellation of the forecast increase in the contribution from brake and tyre wear by a forecast decrease in the exhaust contribution, although both contributions are subject to large uncertainties. For ground-level airport-related emissions, airport-related traffic on the designated network is the source category giving the second largest contribution after aircraft for both pollutants. These emissions are more spread out spatially than those from aircraft on the ground and from airside vehicles. The contribution from car parking and taxis is a small fraction of the total ground-level emissions for either pollutant. The NO_x emissions from non-airport traffic on the network are about 2.1 times the emissions from airport-related traffic; for PM_{10}, emissions from non-airport traffic on the network are about 2.5

[3] Non-ATMs are movements not counted as Air Transport Movements, for example positioning movements. ATMs are limited to 480,000.

times the emissions from airport-related traffic.

The 2010 baseline forecast for airport-related landside road-vehicle NO_x (PM_{10}) emissions on the road network (within the defined 12km x 9km rectangle) is lower by 15% (12%) than the 2002 estimate for the same network area. The predicted increase in airport-related traffic is more than offset by the lower average emissions per vehicle-km for the national fleet in 2010. The non-airport traffic NO_x (PM_{10}) emissions on the network are predicted to fall by 41% (31%) between 2003 and 2010, with this larger reduction reflecting the lower expected rate of increase of background traffic on the network compared to LHR-related traffic in the near vicinity of the airport. The airport-related traffic on the network is forecast to increase by a greater fraction than the fractional increase in passenger numbers because transfer passengers are a smaller fraction of the total in 2010.

The 2010 baseline forecast for airside-vehicle NO_x emissions is 29% lower than the 2002 estimate: the predicted increase in airside vehicle activity (assumed to be broadly in line with passenger throughput) is more than offset by the lower average NO_x emission factors for the baseline vehicle fleet in 2010. The decrease is greater for road vehicles because of the impact of Euro IV and IV+ standards whereas for off-road vehicles no standards beyond Stage 2 have been included. Similarly, the 2010 baseline forecast for airside-vehicle PM_{10} emissions is 41% lower than the 2003 estimate, for the similar reasons. However, for PM_{10}, the decrease is greater for off-road vehicles than for road vehicles, but this is the result of adding in a contribution from fugitive (brake and tyre wear) PM_{10} emissions for the road-vehicle but not for the off-road category.

For both NO_x and PM_{10}, the contribution to near ground emissions arising from on-airport heating plant is not insignificant, but the contribution to annual-mean ground-level concentrations is expected to be small, after taking account of boiler-house stack height. The predicted emissions are higher in 2010 than in 2003, in line with an anticipated (small) increase in the heat energy use on the airport.

It is clear from the above that some emissions contributions are predicted to be higher in 2010 than in 2002 and some lower. Given the different spatial distributions associated with the different source categories (and the important background contribution to concentrations), it is difficult to predict the net impact of these changes in emissions on the total annual-mean airborne concentrations without undertaking a dispersion modelling exercise.

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