Technical Note: Climate Change

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Civil Aviation Authority
Aviation House
Beehive Ring Road
Crawley
West Sussex
RH6 0YR

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Enquiries regarding the content of this publication should be addressed to: environment@caa.co.uk

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1.1 This technical note serves as supporting documentation for the data analysis outlined in the Climate Change chapter in the Aviation Environmental Review 2025 (AER). It explains how the fuel flow and CO_{2e} values used in the Climate Change chapter were generated, first by focusing on the data used to calculate CO_{2e} in the Climate Change chapter. It then summarises the methodology developed by the CAA Emission Database Model (EDB) to generate CO_{2e} data in support of the key findings within the 'Climate Change: GHG Emissions' chapter. It describes key elements of the model, including data sources, general methodology, model scope, assumptions, and limitations. Finally, it discusses data gaps and highlights how future developments may improve the accuracy of the model's predictions.

CAA Emissions Database

1.2 The CAA Emissions Database (CAA EDB) is internally developed and designed by the UK CAA as a means of independently analysing UK civil aviation greenhouse gas emissions. The CAA EDB utilises a time-based approach and is compliant with the IPCC Tier 3 type of methodology as described in the 2006 IPCC Guidelines for National Greenhouse Gas Inventories and the 2019 Refinement Guidelines. Currently, the main purpose of the database is to assess greenhouse gas emission trends, including how trends are changing, the reason for the change, and potential areas for improvement. The UK CAA EDB does not align with specific UK reporting frameworks. Any data presented in the AER should not be used in greenhouse gas inventories submissions, and the reader must instead consult relevant official means and references for submissions.

Data Sources

1.3 The CAA Emission Database Model combines data from EUROCONTROL Advanced Emission Model (version 2.6.2) (AEM) and BADA (version 3.16) to calculate fuel burn and CO_{2e} emissions (per flight phase and total) for each air traffic movement.

1.4 Airport mapping referenced within the model uses CAA UK airport data (sometimes referred to as AvStats) alongside a manually curated dataset to cover data gaps. Both data sources contain airport location-related information, including ICAO code, airport name, geographic region, and location.

1.5 The manually curated dataset included additional data from the DEFRA and EMEP/EEA Workbook - datasets containing Turboprop engines, including landing and take-off cycle (LTO) fuel flow and emissions indices. On average, 90% of turboprops air traffic movements, that contained both LTO and CCD values, are covered by our analysis.

1.6 Wide body and narrow body aircraft classification is categorised based on internal reference tables.

1.7 Four flight distance groupings (0-500km, 500-1500km, 1500-4000km and >4000km) were used, based on the Great Circle Distance (km) calculated from the shortest distance between the airport pair coordinates.

General Approach to Methodology

1.8 The basis for the greenhouse gas emissions estimate is aircraft fuel burn over a full flight. The CAA EDB utilises a so-called 'time-based approach', as opposed to distance-based approach. This means the estimates are based broadly on time spent in the air, rather than, for example, a nominal Great Circle distance travelled, and thus incorporate actual airborne flight inefficiency. Time spent in flight is separated into two sub-categories:

- operation below 3,000 feet above the airfield (the ICAO Landing & Take-off (LTO) cycle) and
- Climb, Cruise and Descent (CCD) phases above 3,000 feet.

1.9 The primary input data for the CAA EDB is 'EUROCONTROL Network Manager Interactive Reporting – Flight List dashboard (NMIR)'. Monthly flight path records for UK departures and arrivals are requested from the NMIR Flight List dashboard. For AER 2025, the datasets cover the period 2019 to 2024. The monthly flightpath records contain flight related information, such as departure airport, arrival airport, actual arrival and departure time, and aircraft type.

1.10 ICAO standard times in mode are used for the LTO cycle of flight (Taxi-in/out, Take-off, Climb-out, Approach and Landing). Time outside of the LTO cycle is calculated by subtracting flight duration excluding taxi times, and ICAO Climb/Approach/Landing times, from the total flight duration.

1.11 For the LTO cycle, fuel burn data was extracted from the ICAO Aircraft Engine Emissions Databank. To calculate the fuel burn for each ICAO LTO phase, we used the most common engine type for each ATM within the ICAO Aircraft Engine Emissions Databank as defined by the EUROCONTROL AEM mapping table. Fuel burn data was then multiplied by the number of engines.

1.12 For the climb and descent phase, fuel burn is calculated either up to 35,000 ft, or up to the maximum operating altitude for each aircraft type - whichever is lower. Fuel burn during cruise is calculated based on the EUROCONTROL BADA nominal aircraft weight and assumes that an aircraft cruises at an altitude of 35,000ft or its maximum operating altitude for each aircraft type, whichever is lower. Cruise flight time was calculated by subtracting the LTO climb/descent cycle times and the nominal climb/descent time to/from cruise altitude calculated by EUROCONTROL BADA from the total flight time reported by the EUROCONTROL Network Manager.

1.13 For flights under 200 nm, a cruise altitude of 35,000 ft is not typically reached. In such cases, the calculation was amended to assume a fixed cruise time of 5 minutes. The cruise altitude was then calculated by subtracting half of the new fixed cruise time (5min) from both the climb and descent phases, and the cruise fuel burn calculated for the new cruise altitude.

1.14 Greenhouse gas emissions for individual flights, expressed as CO_{2e}, are calculated by applying the year-specific conversion factor. The conversion factor is set by the UK Government on yearly basis, depending on the fuel properties over a given year, and accounts for CO_2, CH_4 and N_2O greenhouse gas components.

Scope of GHG Reporting

1.15 Domestic flights – Flights which departed and landed within the UK (England, Scotland, Wales and Northern Ireland) and between the UK and Crown Dependencies.

1.16 International flights – Flights which departed the UK and/or Crown Dependencies and arrived in another country.

1.17 A flight that departs the UK, lands in the UK or Crown Dependencies, then departs again and lands in another country, is recorded and treated as two separate flights: one domestic and one international. Components of emissions included in reported emissions from civil aviation are both cruise and LTO cycle emissions from both international and domestic aviation. Cruise emissions from international flights are only calculated for aircraft departures from UK airports or Crown Dependencies as listed above.

1.18 Military, ‘other operations’, and flights with unidentified ICAO airport codes (for either departure or arrival) are excluded from reported figures.

CAA EDB Benchmarking with Reporting Frameworks and Other Comparisons

1.19 Benchmarking was undertaken during the development on the CAA EDB to validate the outputs generated by the database. The reporting frameworks against which benchmarking was done are listed in this section.

DUKES Tables

1.20 The predicted fuel consumption on a per-flight and aggregated basis at annual level for the years 2019-2024 was compared with the total inland fuel deliveries documented in the national statistics on fuel consumption, DUKES tables.

1.21 Aviation fuel consumption presented in DUKES tables include both civil and military fuel usage. Military fuel use was subtracted from the DUKES totals to provide an estimate of the civil aviation consumption.

1.22 According to the IPCC Guidelines, national total emissions must be based on fuel sales. Therefore, the estimates for aviation fuel consumed, as published by DESNZ, are adjusted to the fuels sold as reported in DUKES. For conventional jet fuel, deviation from the modelled CO_{2e} prior to adjustment, as reported in the UK Greenhouse Gas inventory, is within 5%. A similar level of deviation in CO_{2e} was observed for the aggregated annual fuels modelled with the CAA EDB. As CAA EDB does not scale the fuel up to the DUKES tables, the modelled CO_{2e} emissions with the CAA EDB were found to be acceptable for the AER reporting.

1.23 The AER does not adjust the modelled CO_{2e} to the DUKES tables. This is to allow for natural alignment in fuel flow predictions through better representation of the UK fleet and improved modelling assumptions as a part of potential future development of the CAA EDB. The data presented in this AER is therefore not applicable for inventory submissions, but can be used as an indicator for CO_{2e} historic trajectory change, and as a high-level indicator of the major contributors to CO_{2e} at domestic, international and airport level.

Paris Agreement and UNFCCC Reporting Framework

1.24 Additionally, benchmarking of model outputs was carried out against the UK Greenhouse Gas Inventory, 1990 to 2023, a yearly domestic and international CO_{2e} emission inventory reported as part of commitments under the Paris Agreement and UNFCCC. Larger differences between this data and the CAA EDB were observed within domestic emission comparisons, which were expected, in part due to adjustments made to the calculation of fuel burn and CO_{2e} for shorter flights within the model.

Comparison of the CAA EDB Fuel Burn Estimates with FATHOM Dashboard

1.25 Cross-checks for a sample of individual flights were performed against the EUROCONTROL FATHOM Interactive Dashboard. This confirmed the amended methodology used for the CAA EBD provided satisfactory fuel flow estimates for ultra-short haul flights. There was good alignment between the CO_{2e} predictions generated by the CAA EDB and the FATHOM Dashboard for short-haul flights. Larger deviations were observed for ultra-short haul flights, in line with the level of uncertainty expected when modelling this type of operations.

Input Gap Analysis

1.26 Some instances of data gaps in the input data for aircraft and corresponding engine types were observed. This resulted in fuel burn and therefore CO2e emissions not being calculated for the LTO phase and CCD phase for a small number of flights (<3%). Most of the affected flights were international short- and medium-haul scheduled flights. For flights with missing data for the LTO phase, the CCD fuel burn is still calculated, and vice versa, which forms the larger part of the full flight emissions.

1.27 Flights with missing CO_{2e} estimates, due to absent LTO and/or CCD data, contribute to a slight reduction in estimated CO_{2e} in a given year. This reduction is observed consistently over the reporting period 2019-2024. This underprediction of CO_{2e} is well within CAA EDB modelling assumptions.

1.28 The aspiration is to reduce these data gaps as a potential future development. The CAA EDB is set to develop further in the following years, in line with the AER Roadmap, which may lead to a reassessment of CO_{2e} data between 2019-2024. However, any identified trends are not expected to change significantly. Further development is expected to enable closer alignment with published statistical data, such as, for example, the Digest of UK Energy Statistics DUKES tables.