ICAO Carbon Emissions Calculator Methodology

Air Freighter

Version 1

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1. Introduction

Cargo can be shipped by air in the belly compartment of passenger aircraft or via a dedicated cargo aircraft (air freighter). This document presents a methodology developed for estimating the amount of carbon emissions (CO_2) generated by freighters only.

This methodology is implemented in the freighter functionality of the ICAO Cargo Carbon Emissions Calculator.

2. Predictive estimate on air freighter carbon emissions

This methodology provides information to the user in advance of the shipment (pre-flight). It requires a minimum amount of information from the user, since only the origin and destination cities are required along with the weight of the package being shipped.

2.1 General Description of the Methodology

Similar to the passenger methodology, it applies the ICAO Fuel Formulas to estimate the fuel consumption of freighter aircraft based on the distance flown. Air freighter load factors data are then used to apportion the emissions associated with the flight to the weight of the package carried. As for the passenger methodology, a weighted average of the carbon emissions is computed based on the traffic (type of aircraft used and frequency of flights). The methodology covers direct flights from air freighter route pairs included in the Common Operations Database (COD)[1].

2.2 Calculation Procedure

As illustrated in Figure 1, the methodology combines data from several sources in order to estimate fuel burn associated to the shipment of a package. The fuel burn (in kg) is then converted to CO_2 emissions (in kg) by multiplying it by a factor of 3.16.

CO_2 emissions (kg) per kg carried = 3.16 * (Total fuel burn / Kg available)* load factor

Where: **Total fuel burn(kg)** = The weighted average of the fuel used by all flights departed from the origin airport in order to reach the destination airport. The weighting factor is the ratio of number of departures for each equivalent aircraft type, to the total number of departures.

Kg available = the total number of kilograms available on all flights serving the given city pair.

Load factor = the ratio calculated from ICAO statistical database (TPS) based on number of freight transported and the number of kilograms available in a given region.

3.16 = constant representing the number of tonnes of CO_2 produced by *burning* a tonne of aviation fuel.

[1] https://www.icao.int/environmental-protection/pages/modelling-and-databases.aspx

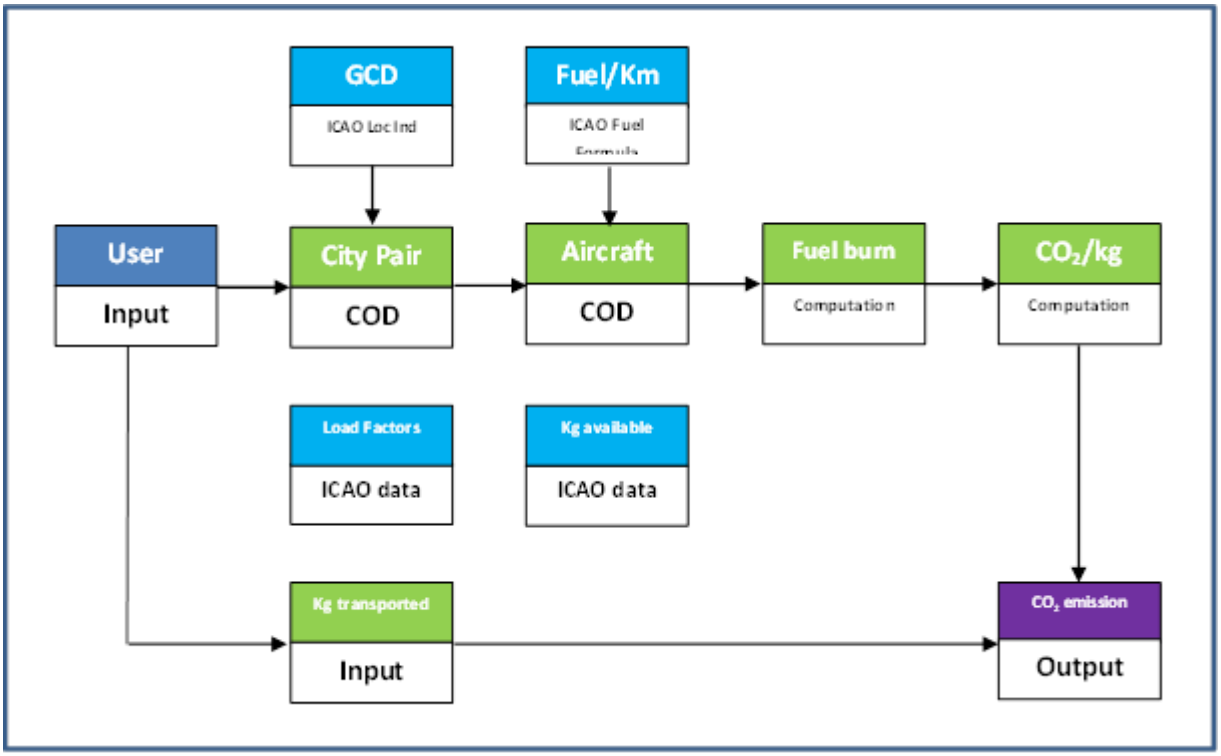

Figure 1. Overview of data sources used by the methodology.

City Pair: Obtained from the Common Operations Database (COD) based on ICAO airport codes.

GCD (Great Circle Distance): GCD is by definition the shortest distance between two points on the surface of a sphere. This distance is calculated by using the geographical coordinates of the two points concerned. The coordinates for the airports are obtained from the ICAO Location Identifiers database (ICAO Doc 7910). Once the GCD is calculated, it is then corrected by a factor depending on the distance between the two airports concerned. (see also table 1 below).

Load Factors: The average generic factors considered for the purpose of this calculation are sourced from the Traffic by Flight Stage database (TFS) which collects air carrier city-pair specific traffic data by aircraft type produced on an annual basis, and domestic traffic and operational data, both collected by ICAO, as well as data based on the flight schedules published by the air carriers.

Fuel/Km: This information, per aircraft model, is obtained from the ICAO Fuel Formula database.

Kg available: This is the number of kilograms carried as freight in the aircraft (i.e. the maximum payload), available from the COD.

User input – Origin and destination airports and the number of kilograms carried as freight. The database is searched only for all direct flights.

Traffic data– An air freighter load factor is assigned to the user-defined city-pair, based on the corresponding regions.

Aircraft mapping– From the COD, the scheduled aircraft is identified in the ICAO Fuel Formula database.

Fuel burn– The fuel burn is extrapolated from the ICAO Fuel formula. The factors considered include load factor, flight distance, the proportion of the overall payload represented by air freighter traffic, and type of aircraft flown. The amount of fuel used is the weighted average of total fuel burnt based on the frequencies of the scheduled aircraft types flown.

CO_2 (kg) per kg carried– Using the trip distance, aircraft fuel consumption, load factor from the region, and the number of kilograms available, the methodology calculates the CO_2 emissions (kg) associated to each kilogram transported, as follows:

CO_2 emissions (kg) per package– Depending on user selection (number of kg carried), the total CO_2 emissions (kg) is estimated by multiplying the weight of freight (kg) transported with CO_2 emission (kg) per kilogram.

GCD Corrections

As with the passenger methodology, the Great Circle Distance (GCD) (in km) between the input airports is used, in order to estimate the fuel burned (in kg), and thus estimate the CO_2 emissions.

A correction factor is introduced in order to take into account the distance flown in excess of the GCD due to stacking, traffic and weather-driven corrections.

The table below shows the GCD correction factor used.

GCD	Correction to GCD
Less than 550 Km	+ 50 Km
Between 550 Km and 5500 Km	+ 100 Km
Above 5500 Km	+ 125 Km

Table 1: GCD Correction Factor

Load Factor

The Load Factor used is an average calculated on a regional basis. The data are obtained from reported data submitted by States to ICAO. (See table 2)

Region	LF
AFRICA	57%
ASIA/PACIFIC	64%
EUROPE	68%
LATINAMERICA/CARIBBEAN	71%
MIDDLE EAST	47%
NORTH AMERICA	58%
Total	60%

Table 2: Load factor

3. Discussion of Sensitivities

In any modelling exercise the desire for accuracy is moderated by the level of complexity the analyst is willing to accommodate. In the case of this ICAO methodology, an attempt has been made to account for the principal factors which define an individual's aviation carbon emission footprint while assessing each at a level which recognizes the inherent uncertainty underlying many of the assumptions embedded in this approach.

Assumption Regarding Air Shipment – This methodology assumes that the item has shipped by air from the origin city's airport to the destination city's airport. No estimate of the emissions associated with the portion of the item's journey by any other mode of transportation is included in this calculation.

Great Circle Distance – while it is understood that air travel does not occur in a straight line between two points, actual flown distance to be collected from the air carriers, or from a more accurate trip distance database showed to be not feasible for the time being.