



# 2023 airlines' emissions analysis

## Methodological note

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April 2024

### 1. Introduction

Every April, the European Commission releases compiled EU and Swiss emissions trading system (ETS) emissions data<sup>1</sup>. T&E analyses this data to understand the performance of airlines. Since last year, we extended the scope of the analysis to all emissions from flights departing from EU27, Norway, Iceland, Switzerland and the UK - hereon called EU31, to put the ETS pricing mechanisms in perspective. This was done by calculating the aircraft fuel consumption of scheduled flights data, from OAG<sup>2</sup>, using Eurocontrol's fuel consumption methodology<sup>3</sup>. Our analysis focuses on 2023 and 2022 emissions, as well as 2019 emissions, as the historical peak year of European aviation emissions, prior to the covid crisis.

This methodological note details how the emissions from the different scopes were estimated in order to build the top polluting airline ranking, the market share changes between low cost and legacy carriers, the most frequented and most polluting routes, and how we deduced the effective average carbon pricing paid per airline.

### 2. Geographical scopes and corresponding emissions sources

Our analysis covers emissions from flights departing from EU31. Depending on the destination, emissions from those flights are included in one of the three current Emission Trading Systems in Europe - the EU ETS, the Swiss ETS, and the UK ETS - or not covered by any of them.

Since the agreement between Switzerland and the EU on linking their ETSs in 2020, airlines report emissions and allocations from flights within Switzerland, and departing from Switzerland to the EEA<sup>4</sup> in a separate section in the ETS log (called "CH emissions" and "CH allocations").

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<sup>1</sup> [https://ec.europa.eu/clima/policies/ets/registry\\_en#tab-0-1](https://ec.europa.eu/clima/policies/ets/registry_en#tab-0-1)

<sup>2</sup> <https://www.oag.com/>

<sup>3</sup> <https://www.eea.europa.eu/publications/emep-eea-guidebook-2019/part-b-sectoral-guidance-chapters/1-en-ergy/1-a-combustion/1-a-3-a-aviation-1/view>

<sup>4</sup> The EEA includes the EU member states, Norway and Iceland.

In 2021 the scope of the EU ETS was reduced. Aircraft operators now report emissions from UK domestic flights and flights from the UK to the EEA under the UK ETS<sup>5</sup>. Since UK ETS verified emissions were not made available yet, we estimated them from OAG data (Table 1).

Table 1 gives an overview of the ETS coverage of emissions depending on the countries of departure and arrival of a flight, as well as the source used in our analysis to estimate the corresponding emissions for airlines, both in 2023 and 2019.

Geographical scope of emissions	ETS coverage in 2019	ETS coverage in 2023	Source for 2019 emissions	Source for 2023 emissions
Emissions from flights within the EEA <sup>6</sup>	EU ETS	EU ETS	EU transaction log (Section 3)	EU transaction log (Section 3)
Emissions from flights from the EEA to the UK	EU ETS	EU ETS	EU transaction log (Section 3)	EU transaction log (Section 3)
Emissions from flights from the UK to the EEA and Switzerland	EU ETS	UK ETS**	EU transaction log (Section 3)	OAG, Eurocontrol* (Section 4)
Emissions from Switzerland to the EEA	Not covered	Swiss ETS	OAG, Eurocontrol* (Section 4)	EU transaction log (Section 3)
Emissions from the EEA to Switzerland	Not covered	EU ETS	OAG, Eurocontrol* (Section 4)	EU transaction log (Section 3)
Other emissions, from flights departing from EU31 that are not included in the above categories	Not covered	Not covered	OAG, Eurocontrol* (Section 4)	OAG, Eurocontrol* (Section 4)

Table 1: Geographical scopes, ETS coverage and emission sources. \* Estimated emissions. \*\*Official UK ETS emissions are to be released later this year.

### 3. EU transaction log

#### 3.1 Emissions filling

We fill emissions if an account has not yet reported their emissions (i.e., they have -1 reported), is listed as open and is not excluded from reporting. Typically, there are a certain number of accounts that do not report their emissions on time. For the aviation sector, the operators that have not reported their 2023 emissions in time accounted for 12% of aviation emissions in 2022. For these operators we multiplied their 2022 verified emissions by the average growth in aviation between 2022 and 2023 (11%).

<sup>5</sup> Emissions from flights from the EEA to the UK remain under the EU ETS scope ([source](#)).

<sup>6</sup> The EEA includes the EU27, Norway and Iceland.

Although the same process is applied on the majority of airlines that have not reported their emissions, a more detailed analysis was undertaken for several specific airlines. In 2023, 13 airline companies within the scope of our study<sup>7</sup> did not fill their emissions in time, and were not reported in the ETS release from the 4<sup>th</sup> of April. For 9 of these airlines (Air China Limited, Fedex, Air France, ASL Airlines France, Air Austral, Air Caraibes, French Bee, Corsair, TAP Portugal) emissions were eventually added in the ETS log. At the time of the analysis (4th of April), Condor Flugdienst GmbH, Polish Airlines, Transavia France and Ryanair SUN, data were not uploaded on ETS log.

For these four airlines, the following approach was undertaken: for Condor Flugdienst, Polish Airlines and Transavia France, we used OAG data to estimate the amount of emissions covered by the EU and Swiss ETSs. For Ryanair SUN, we calculated the average growth between 2022 and 2023 of other subgroups of Ryanair (see section 3.2), and multiplied Ryanair SUN 2022 emissions by this growth factor to estimate their emissions in 2023. As a result, only 5% of the EU and CH ETS emissions had to be estimated.

### 3.2 Airline Grouping

Some airlines have different accounts in different member states of the EU. For all intents and purposes, these different accounts are attributable to an airline based on whether or not a passenger believes they are flying with a certain company or not. EasyJet, for example, has four accounts, however they do not have four separate airlines, or websites to book those flights, or are operated by different entities. This differs from subsidiaries, for example Lufthansa owns Brussels Airlines, but Brussels Airlines is a different brand than its parent company. The airlines that we grouped together are shown in the table below, under an airline alias that is the commonly used name.

Airline ALIAS	Identifier in ETS log	Note
TUI	30011.TUI AIRLINES BELGIUM	
	Handelskonto TUIfly GmbH	
	TUI Airlines Nederland BV	
	TUIfly Nordic AB	
	Thomson Airways Limited	
Ryanair	Ryanair Sun S.A.	Has not reported its emissions at the time of analysis
	Ryanair UK Limited	
	Ryanair DAC	

<sup>7</sup> i.e. highlighted in one our analysis

ASL	27011.ASL Airlines Belgium	
	ASL AIRLINES FRANCE SA	
	Farnair Switzerland	Account closed
	ASL Airlines (Hungary) Kft.	Account closed
	ASL Airlines (Ireland) Limited	
FedEx	11102.FedEx Express Corporate Aviation	
	FEDERAL EXPRESS CORPORATION	
EasyJet	easyJet Switzerland SA	Account closed
	EACL ETS Account	
	EASYJET UK LIMITED	
	easyJet Europe Airline GMBH	
Norwegian	Norwegian Air Shuttle AOC	
	Norwegian Air Sweden AOC AB	
	Norwegian Air International Limited AOHA	Excluded
	Norwegian Air UK	
DHL	European Air Transport Leipzig GmbH	
	DHL Air Limited	
Iberia	IBERIA LAE SA OPERADORA SU	
	Iberia Express, S.A.	
Eurowings	Handelskonto der Germanwings GmbH	
	Eurowings GmbH	
Transavia	TRANSAVIA FRANCE	Has not reported its emissions at the time of analysis
	Transavia Airlines	
Wizz air	WIZZ AIR UK LIMITED	
	WIZZ AIR HUNGARY LTD	
British Airways	British Airways PLC	
	BA CITYFLYER LIMITED	

Deutsche Lufthansa AG	Deutsche Lufthansa AG	
	Lufthansa Cargo AG	
Qatar Airways	Qatar Airways	
	QATAR EXECUTIVE	
SunExpress	SunExpress ETS holding account	
	ETS Konto SunExpress Deutschland	Account closed
Air China	Air China Cargo Co., Ltd	
	Air China Limited	
Singapore Airlines	27975.SINGAPORE AIRLINES CARGO PTE LTD	Account closed
	Singapore Airlines Limited	

Table 2: Account combined in the ETS

## 4. Estimates of emissions from the remaining geographical scopes

The emissions not covered by the EU and Swiss ETS are estimated by calculating the aircraft fuel consumption of scheduled flights data from OAG, to which we apply the emission factor of kerosene. Fuel consumption from aircraft is calculated following Eurocontrol's fuel consumption methodology.

### 4.1 OAG flight coverage

Whereas cargo integrators (e.g. DHL) report their emissions in the ETS log, they are excluded from OAG coverage due to the economic sensitivity of the data. As a consequence, although ETS emissions from cargo integrators are included in the analysis, emissions from cargo integrators outside the ETS scope are excluded. This inconsistency is deemed minimal since emissions from full cargo operators were only 5% of all emissions in 2018<sup>8</sup>.

Other types of flights such as flights from military aviation or governmental and humanitarian flights for instance are not covered by OAG. This results in lower number of flights when comparing with other data sources, such as Eurocontrol<sup>9</sup>. However, the impact on emissions is estimated to be minimal, as detailed in section 4.2.

As the number of flights is not reported in the ETS log, all data on flights and market share are derived from OAG, and therefore only include scheduled passenger flights (including flights with belly cargo), and charter flights.

### 4.2 Comparison of OAG estimates with other data sources

We calculate that the emission from flights departing from EU27 using OAG data are 4.6% below the emissions from UNFCCC in 2019<sup>10</sup> and that emissions from the 2019 ETS scope are 2% below the verified emissions from the EU transaction log. The same comparison for 2023 shows that OAG emissions are 5% higher than ETS emissions calculated from the EU transaction log. We further compared emissions calculated using OAG for 2019 and 2023 to emissions published by Eurocontrol for these two years. We calculated that our data are respectively 3.1% and 4.8% below Eurocontrol emissions<sup>11</sup>. Table 3 shows, by airline, the comparison between the emissions calculated from OAG, and the emissions reported under the EU ETS for the years 2019 and 2023. Although the OAG estimates of ETS emissions are not used in our analysis - we use OAG estimates only for the emissions not covered by the EU ETS, this comparison aims at checking the accuracy of the estimates from OAG at the airline level.

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<sup>8</sup> [https://www.destination2050.eu/wp-content/uploads/2021/03/Destination2050\\_Report.pdf](https://www.destination2050.eu/wp-content/uploads/2021/03/Destination2050_Report.pdf)

<sup>9</sup> <https://ansperformance.eu/data/>

<sup>10</sup> UNFCCC's scope includes emissions from private jets. Therefore, the comparison is made after adding T&E own private jets' emission estimates to the emissions calculated from OAG.

<sup>11</sup> [https://ansperformance.eu/data/#img-srcimageseffectl\\_env2jpg-width60-height60-altco2-emissions-by-state-co2-emissions-by-state](https://ansperformance.eu/data/#img-srcimageseffectl_env2jpg-width60-height60-altco2-emissions-by-state-co2-emissions-by-state)

Scope of emissions	2019 EU ETS scope (incl. flights to and from the UK)			2023 EU ETS scope (incl. flights from and to Switzerland, but excl. flights from the UK)		
	OAG estimated emissions 2019 (Mt)	Reported ETS emissions in 2019 (Mt)	Difference OAG - ETS (Mt)	OAG estimated emissions 2023 (Mt)	Reported ETS emissions in 2023 (Mt)	Difference OAG - ETS (Mt)
Ryanair	11.1	10.5	0.59	11.7	10.5	1.1
Deutsche Lufthansa AG	4.5	4.4	0.10	3.5	3.4	0.1
British Airways	2.8	2.9	-0.08	1.1	1.1	0.0
Air France	2.5	2.5	-0.02	2.2	2.0	0.3
Easyjet	6.5	6.6	-0.04	4.1	3.6	0.5
KLM-Royal Dutch Airlines	2.1	1.9	0.18	1.9	1.7	0.3
Emirates	0.1	0.0	0.01	0.1	0.1	0.0
Wizz Air	2.7	2.6	0.09	2.9	2.8	0.1
Iberia	1.7	1.3	0.38	1.7	1.2	0.4
United Airlines	0	0	0	0.0	0.0	0.0

Table 3: comparison of OAG data with ETS data from the EU transaction. Note that the scope of the ETS in 2023 is different from the one in 2019, and that emissions are not directly comparable from one year to the other.

### 4.3 Top 10 polluting airlines

Airlines are ranked by their total departing emissions from flights departing from EU31. We also ranked top 10 airlines based on their departing emissions from France, from Germany, and from the United Kingdom. It should be noted that our emissions estimates for the last airline of the EU31 top 10, TUI(3.4 Mt), were close to the emissions estimates of United Airlines (3.6 Mt), which is the last airline in the top 10 ranking.

## 5. Market share change between 2019 and 2023

In this analysis, we define the market share as the share of flights departing from an EU31 airport operated by a certain airline. The number of flights operated by an airline is directly derived from OAG data. For the distinction between Mainlines and Low Cost airlines we followed the classification proposed by OAG<sup>12</sup>. In addition to this classification, we distinguished between specific categories of airlines (Table 3). The same analysis was performed for flights departing from France, from Germany, and from the United Kingdom.

<sup>12</sup> <https://www.oag.com/blog/what-are-low-cost-carriers-aviation>

Category	Airline
European flag and legacy carriers	Finnair
	Scandinavian Airlines
	TAP Portugal
	Alitalia
	LOT - Polish Airlines
	Iberia Airlines
	Austrian Airlines
	Brussels Airlines
	Aer Lingus
	Air France
	KLM
	Lufthansa
	British Airways
	Main European Low Cost Carriers
Ryanair	
Wizz Air	
Selected 3 <sup>rd</sup> Countries Carriers	Turkish Airlines
	Qatar Airways
	Emirates Airlines
	Etihad Airways
	United Airlines
	Delta Air Lines



	Ethiopian Airlines
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Table 4: Airline categories

## 6. Effective price of carbon emissions

For each airline, we calculate the effective prices of a tonne of CO<sub>2</sub> emitted. To do so, we divide the amount of money they pay for their emissions priced under the ETSs by their total emissions from flights departing from EU31. Under the EU ETS scheme, around 500 aircraft operators<sup>13</sup> are allocated free allowances. For the estimated pricing in 2024 we took into account that next year both EU and UK free allowances are planned to be reduced. For EU free allowances, a 25% phase out of free allowances will be applied, and a rate of 2.2% free allowances will be applied to UK free allowances. Emissions priced under an ETS are emissions covered by this ETS, minus the number of free allowances. We use an average carbon price of €85.3/tonne of CO<sub>2</sub><sup>14</sup> for the EU and the Swiss ETS (that are linked), and €62.24/tonne of CO<sub>2</sub><sup>15</sup> for the UK price.

It is important to note that for carbon pricing analysis at the EU scale, we did not include emissions of flights from the UK to Switzerland under priced emissions, as we were not aware of the changes of scope between 2022 and 2023 in the UK ETS regulation. These emissions accounted for 0.26 Mt of CO<sub>2</sub> and were distributed between nine airlines. Per airline, the difference is therefore minimal. For our analysis of carbon pricing at the UK scale however, flights from UK to Switzerland were accounted for under priced emissions to follow the latest regulation.

## 7. Most frequented and most polluting routes in Europe

Using frequencies of flights departing from EU31 from OAG, we estimated the most frequented and most polluting routes in 2023. The regrouping of airports per European cities used in our analysis is presented in Table 5. Our data set only encompasses flights departing from EU31 airports. Therefore for extra EU31 flights, data were multiplied by 2 to estimate numbers of flights and CO<sub>2</sub> emissions from return flights.

City	Airport	IATA Code
Brussels	Brussels Airport	BRU
	Brussels South Charleroi Airport	CRL
Hamburg	Hamburg Airport	HAM
	Hamburg Finkenwerder Airport	XFW

<sup>13</sup>

[https://ec.europa.eu/clima/eu-action/eu-emissions-trading-system-eu-ets/free-allocation/allocation-aviation\\_en](https://ec.europa.eu/clima/eu-action/eu-emissions-trading-system-eu-ets/free-allocation/allocation-aviation_en)

<sup>14</sup> Ember

<sup>15</sup> Ice.com. Using the 2023 average conversion rate of 1.1619 ([Source](#)).

Berlin	Berlin Tegel International Airport	TXL
	Berlin Schönefeld International Airport	SXF
	Berlin Brandenburg Airport	BER
Belfast	Belfast International Airport	BFS
	George Best Belfast	BHD
Nottingham	Nottingham Airport	NQT
	East Midlands Airport	EMA
London	London Gatwick Airport	LGW
	London Heathrow Airport	LHR
	London City Airport	LCY
	London Stansted Airport	STN
	Southend Airport	SEN
	London Luton Airport	LTN
Glasgow	Glasgow International Airport	GLA
	Glasgow Prestwick Airport	PIK
Gothenburg	Gothenburg City Airport	GSE
	Gothenburg Landvetter Airport	GOT
Stockholm	Stockholm Västerås Airport	VST
	Stockholm Arlanda Airport	ARN
	Stockholm Bromma Airport	BMA
	Stockholm Skavsta Airport	NYO
Tenerife	Tenerife South Airport	TFS
	Tenerife Norte Airport	TFN
Paris	Charles de Gaulle International Airport	CDG
	Paris Orly Airport	ORY
	Paris Beauvais Tillé Airport	BVA
Milan	Milano Linate Airport	LIN

	Malpensa International Airport	MXP
	Il Caravaggio International Airport	BGY
Rome	Leonardo da Vinci Fiumicino Airport	FCO
	Ciampino G.B. Pastine International Airport	CIA
Frankfurt	Frankfurt am Main Airport	FRA
	Frankfurt Hahn Airport	HHN

Table 5: Main cities and their respective airports

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