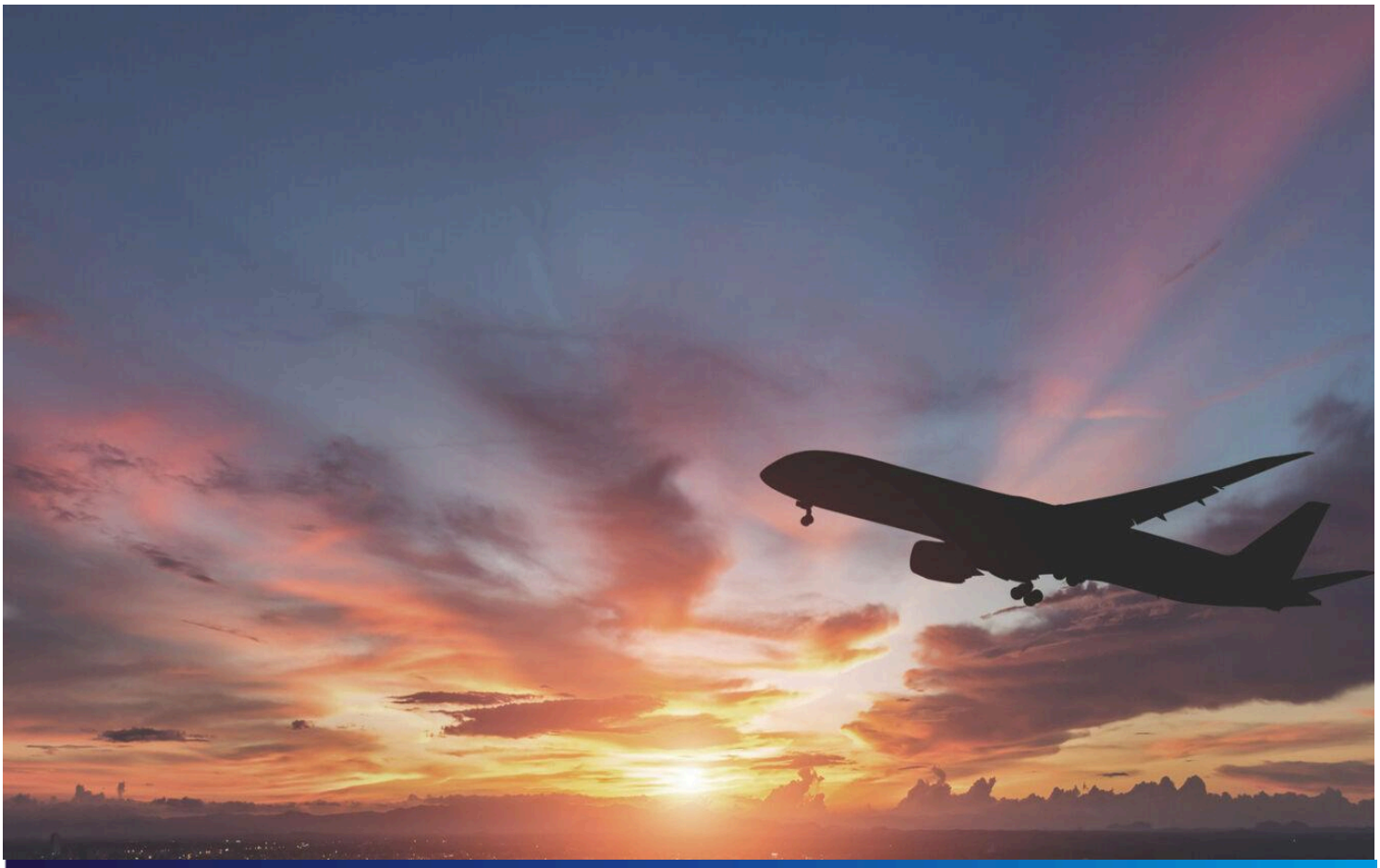

The EU's and ICAO's diverging ambitions to reduce aviation's climate impacts

Final report

For: Carbon Market Watch

November 2024

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KEY TAKEAWAYS

The key differences between the EU ETS for aviation and the CORSIA offsetting scheme are summarised in Table 1 and described in more detail in the sections below.

Table 1 Main differences between EU ETS for aviation and ICAO CORSIA

	EU ETS	CORSIA
Type of scheme	Cap and trade (see definition in Text Box 1 below)	Offsetting (see definition in Text Box 1 below)
Implementation timeline	2012 for both monitoring, reporting and verification (MRV) and cap-and-trade schemes.	2019 for MRV, 2021 for Offsetting scheme (2021-2023 pilot phase, 2024-2026 first phase, 2027-2035 second phase).
Scope of MRV requirements	<u>Routes in scope</u> Flights between and within European Economic Area (EEA) Member States. Flights from EEA Member States to Switzerland and the United Kingdom (UK). Special rules apply to EU outermost regions mentioned in section 1.2. <u>Operators in-scope</u> All commercial operators with the following characteristics: ○ Emit more than 10,000 tonnes of CO_2 (tCO_2) per year on in-scope flights, and ○ Operate more than 243 flights within a four-month period. Non-commercial aeroplane operators emit more than 1,000 tCO_2 emissions per year on in-scope flights.	<u>Routes in scope</u> International flights between ICAO Member States. <u>Operators in-scope</u> Aeroplane operators of commercial flights that emit more than 10,000 tCO_2 per year on international flights.
Scope of offsetting/ETS scheme	Same as the scope of MRV requirements above.	<u>Routes in-scope</u> From 2021 until 2026, offsetting requirements will only apply to international flights between states that volunteer to participate in the pilot and/or the first phases, estimated to capture 63% of reported international aviation CO_2 emissions in 2022. From 2027, offsetting requirements will apply to all international flights, except for: ● Least Developed Countries, Small Island Developing States, and Landlocked Developing Countries; or

	EU ETS	CORSIA
		• States that represent a small share of international aviation activities (in Revenue Tonne Kilometres or RTKs)[1]. The share of international aviation CO_2 emissions that will be captured from 2027 is estimated at 85%, assuming all mandatory participation states join the second phase. <u>Operators in-scope</u> Aeroplane operators with annual emissions below 500,000 tCO_2 are exempt from offsetting requirements, which represented 12% of total reported emissions in 2022.
Emissions subject to carbon price	Surrendered emission allowances equivalent to all CO_2 emissions under MRV. Emissions allowances for aviation are either allocated for free to aeroplane operators or sold through auctions. Operators can also purchase allowances from other ETS sectors. From 2013 to 2023, around 40-55% of the annual reported emissions under MRV were covered by purchased allowances (both in-sector and out-of-sector allowances). Free allowance allocated to aeroplane operators will reduce substantially from 2024, leading to the elimination of free allowance by 2026 when 100% of allowances will be auctioned.	Emissions in excess of the defined baseline. The current baseline is defined as 85% of 2019 CO_2 emissions from 2024. The baseline calculation takes Sector Growth Factor (SGF) into account, which measures growth in total CO_2 emissions subject to offsetting requirements sector-wide. This study estimated that in 2030, emissions to be offset by operators would represent 15% of total reported emissions (or 20% of emissions subject to offsetting requirements). From 2033 the growth factor will be a combination of the SGF (85%) and individual operator growth (15%).
Carbon price level	Price of EU ETS allowances was around 80 EUR/tCO_2 in 2023 and it is expected to gradually increase in the next few years, as fewer emission allowances are available in the market.	Prices for different emissions offset schemes and their credits vary. ICAO estimates suggest prices around 3 EUR/tCO_2 in 2022, with projections to increase to 7 EUR/tCO_2 in 2030. Data on futures market suggests that prices could be significantly higher, at around 7-15 EUR/tCO_2 by 2026.
Non-CO_2 emissions	Directive 2023/958 amended Directive 2003/87/EC in 2023 to include non-CO_2 emissions in MRV reporting scope starting from reporting year 2025. The report should at least contain the three-dimensional aircraft trajectory data available, ambient humidity, and	Not currently monitored nor accounted in the offsetting system. There is no information regarding the inclusion of non-CO_2 emissions at the time of writing. Discussions on non-CO_2 emissions at ICAO level are at the very early stages.

[1] These include the Member States that account for less than 0.5% of total RTKs from international aviation in 2018

	EU ETS	CORSIA
	temperature for the Commission to estimate the equivalent CO_2 emissions per flight. Plans to come up with potential legislative proposal before 2028 based on submitted reports regarding the expansion of EU ETS scope to non-CO_2 emissions. There is no timeline to include non-CO_2 emissions into the emissions coverage for now.	
Use of revenues	EU Member States responsible for auctioning the emission allowance receive most of the revenue generated, with a small fee paid to the common auction platform. This applies to all ETS sectors including aviation. The current allowance auction regulation updated in 2023 stipulates 100% of the aviation allowance revenue received by Member States should go towards climate actions.	The potential primary beneficiaries of the revenue will be the offset project developers, local communities to the project, as well as contributing towards the administrative costs of operating the offsetting credit scheme, including verification and certification providers.

Box 1 Emissions Offsetting versus the Cap-and-Trade system

Offsetting emissions is a strategy used to balance out greenhouse gas emissions from a net emitter by investing in projects that can demonstrate an equivalent reduction of emissions. However, the extent to which emissions are offset heavily depends on the effectiveness, transparency and credibility of eligible programmes. This concept is rooted in the idea of compensating for emissions that are difficult to eliminate directly. Examples of projects reducing or removing carbon emissions from the ecosystem might include reforestation efforts, renewable energy initiatives, or carbon capture and storage. Offsetting schemes do not effectively incentivise in-sector climate mitigation efforts since the price of carbon credits tends to be substantially lower than in-sector abatement costs.

The **cap-and-trade system** sets a total emissions limit that can be emitted by all participants of the system, with the total cap gradually reducing over time. Emissions allowances are permits that allow participants to emit a specific amount of CO_2. Under a typical cap-and-trade system, participants can obtain emissions allowances through two methods: free allocation from the regulatory authority and trade the allowances through auctions. Participants who expect to emit more than their allocated free emissions allowances need to purchase additional allowances in auctions. In contrast, less polluting participants with surplus emissions allowances can trade them through auctions. The trading system creates an economic incentive for participants to reduce emissions, incentivising investments in emission-reduction technologies to reduce the economic cost of purchasing increasingly scarce emissions allowances in the long run.

1. Introduction to EU ETS and CORSIA

Both the European Union Emissions Trading System (EU ETS) and the International Civil Aviation Organisation (ICAO) Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA) seek to address the impacts of carbon dioxide (CO_2) emissions from aviation on the climate through market-based measures.

1.1 CORSIA

CORSIA is a global market-based measure offering a coordinated global approach to reducing carbon emissions from international aviation. CORSIA complements other CO_2 abatement measures, such as technological improvements, operational improvements, and sustainable aviation fuels, by offsetting the non-abated CO_2 emissions with specific, eligible carbon credits that finance a reduction in emissions elsewhere. See Box 1 for more details about the concept of offsetting emissions.

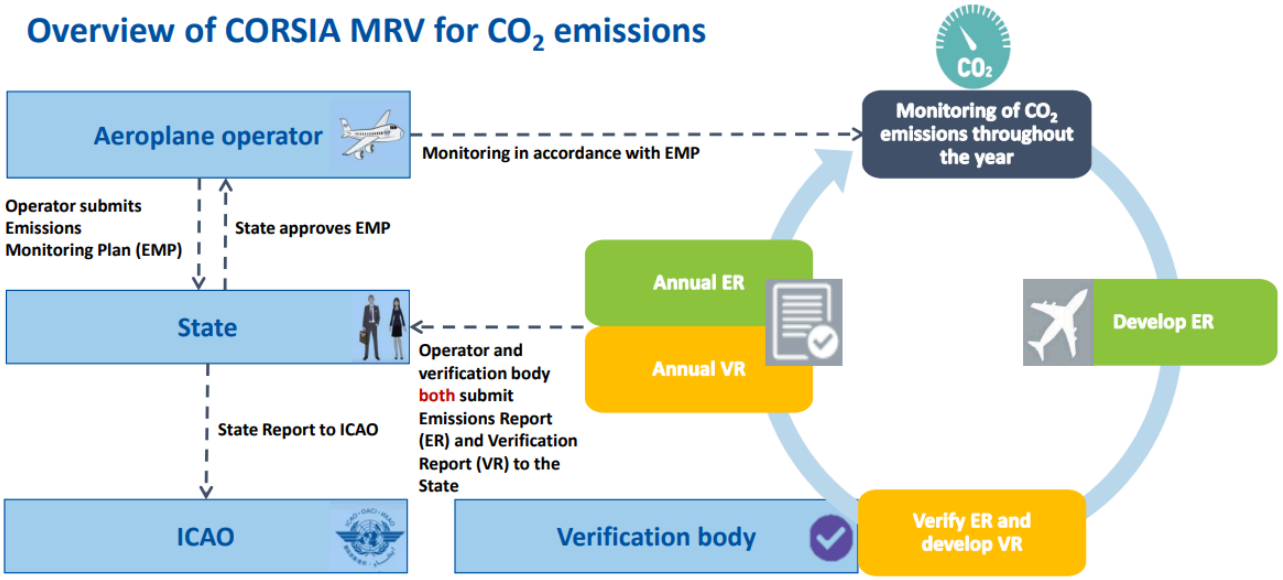
CORSIA is managed by the International Civil Aviation Organization (ICAO), a specialised agency of the United Nations with 193 Member States. ICAO oversees the implementation and compliance of the scheme among the 126 Member States signed up to CORSIA as of January 2024. This involves setting the framework for how emissions are monitored, reported, and offset, ensuring that participating Member States and their aeroplane operators adhere to the agreed protocols to reduce the carbon footprint of international aviation. Member States participating in CORSIA are responsible for collating information submitted by aeroplane operators within their jurisdictions and approving their Emissions Monitoring Plan (EMP) to ensure the methodology applied to account for the CO_2 emissions on international flights by aeroplane operators during the reporting period meets the standardisation methods approved by ICAO.

1.1.1 Monitoring, Reporting and Verification (MRV)

The implementation of CORSIA consists of two main components: the Monitoring, Reporting and Verification (MRV) system and the Offsetting system. The MRV system began in 2019 when all ICAO Member States with international aviation activities were required to monitor and report their CO_2 emissions from international flights. Resultantly, aeroplane operators registered with participating Member States conducting international flights must report their Tank-to-Wake CO_2 emissions on an annual basis. Figure 1 demonstrates the MRV reporting pathways and relationships between stakeholders.

The annual submission of the Emissions Report must contain data collected using the EMP methodology already approved by national authorities, detailing the total CO_2 emissions for the reporting year and demonstrating compliance with CORSIA's requirements. To ensure the reliability and accuracy of the reported emissions, mandatory verification of the Emissions Report must be conducted by an ICAO-approved, impartial, accredited verification body. The verification body should submit the Verification Report to the relevant national authority as part of the MRV requirements.

Figure 1: Stakeholder relationships in the CORSIA MRV system



Source: CORSIA MRV System: Monitoring, Reporting and Verification of CO_2 emissions (Annex 16, Volume IV)[2]

ICAO offers two approved methods, Fuel Use Monitoring Method and CORSIA CO_2 Estimation and Reporting Tool (CERT), to track aeroplane operators' CO_2 emissions depending on the international aviation fuel consumption and the reporting period. Depending on the initial estimation results of the aeroplane operators' CO_2 emission, it dictates which approved practices aeroplane operators can use to report their accurate CO_2 emission in the reporting year. Usually, the Fuel Use Monitoring Method is used by larger aeroplane operators consuming a larger quantity of aviation fuel, while CERT is used by operators with smaller scale operations to estimate and report their CO_2 emissions.

The difference between CERT and the ICAO-approved Fuel Use Monitoring Method is that the former estimates CO_2 emissions based on operational data such as the number of flights, aircraft type, and distances travelled, as opposed to the Fuel Use Monitoring Method, which tracks detailed fuel consumption data. The detailed fuel consumption data collected from one of the five ICAO-approved Fuel Use Monitoring Methods combined with ICAO fuel conversion factor and formula published in the CORSIA Handbook will calculate CO_2 emissions with higher accuracy than CERT. Hence, the Fuel Use Monitoring Method is mandatory for aeroplane operators consuming a larger quantity of aviation fuel annually.

The first step for all aeroplane operators is to check whether they need to report under the CORSIA MRV system. This is done by using CERT to generate an initial result, estimating their annual CO_2 emissions for flights within the CORSIA MRV system scope.

If the CERT result shows the operator consumes more than four million litres of aviation fuel for the reporting period on in-scope flights, the operator is required to report their CO_2 emissions. Depending on the quantity of aviation fuels provided by CERT, Table 2 summarises which approved methods aeroplane operators should use to meet the CORSIA MRV requirements.

Currently, there is no discussion about amending the MRV requirements.

[2] CORSIA MRV System: Monitoring, Reporting and Verification of CO_2 emissions (Annex 16, Volume IV) https://www.icao.int/MID/Documents/2022/CORSIA-SAP%20Seminar/3.%20CORSIA%20MRV.pdf

Table 2: Summary of CORSIA MRV requirements for aeroplane operators based on fuel consumption levels

International flight fuel consumption (million litre/year)	CO_2 emissions equivalent (CO_2e/year)	CORSIA MRV requirements	Share of total reported CO_2 emissions in 2022
Less than 4	< 10,000	Exempt from any MRV requirement	Not reported
Equal to or more than 4 but less than 20	< 50,000	Use CERT to estimate CO_2 emissions	1%
Equal to or more than 20 but less than 200	< 500,000	**2019-2020:** Use CERT to estimate CO_2 emissions **2021 onwards:** Mandatory to calculate annual CO_2 emissions using one of the five ICAO-approved Fuel Use Monitoring Methods	11%
Equal to or more than 200	> 500,000	Mandatory to calculate annual CO_2 emissions using one of the five ICAO-approved Fuel Use Monitoring Methods	88%

Source: ICAO Doc 9501 — Environmental Technical Manual, Volume IV [3]

Note: Share of total reported emissions calculated for each category based on CO_2 emissions data per operator for 2022 available from CORSIA central registry

Aeroplane operators utilising CORSIA Eligible Fuels on international flights are eligible for emissions reduction claims in the CORSIA MRV system. Fuels certified as CORSIA Eligible Fuels must meet certain sustainability requirements and sufficient net emission reduction compared to fossil fuels-based counterparts as set out by ICAO. For aeroplane operators to claim emission reduction with CORSIA Eligible Fuels, the claim must be based on the mass of fuels purchased according to purchasing and blending records. More details on the CORSIA Eligible Fuels criteria are provided in section 1.1.3.

1.1.2 Offsetting system

The compliance periods for the offsetting system are every three years, with the Pilot phase beginning in 2021 and ending in 2023. The current phase, starting from 2024 until 2026, only involves States that are voluntarily participating and accounts for the international flights to and from these participating States by aeroplane operators meeting the relevant requirements. It should be noted that the participation requirement for aeroplane operators in the offsetting system is different from the MRV system. The second phase of the

[3] ICAO Doc 9501 — Environmental Technical Manual, Volume IV https://elibrary.icao.int/reader/446973/&returnUrl%3DaHR0cHM6Ly9lbGlicmFyeS5pY2FvLmludC9wcm9kdWN0LzQ0Njk3MyUzRl9nbCUzRDEqa2x4MW85Kl9nYSpNVGMwTWpBNU5ESTJMakUzTVRnNE9UZzVNRFEuKl9nYV85OTJOM1lETEJRKk1UY3hPVEl4T0RNNU15NHpMakV1TVRjeE9USXhPRE01T1M0d0xqQXVNQS4u?productType=ebook

scheme, starting from 2027 until 2035, will involve mandatory participation for States that meet certain criteria based on their Revenue Tonne Kilometres (RTKs)[4], as highlighted in Table 5.

Essentially, the offsetting system requires aeroplane operators to compensate for any carbon emissions above the CORSIA baseline with carbon credits from eligible emissions unit programmes approved by ICAO, which can be found in the CORSIA Eligible Emissions Units document[5].

The CORSIA baseline, which determines the offsetting requirements for aeroplane operators within the CORSIA Offsetting scope, has increased its ambition over time. Originally, it was intended that CORSIA would deliver "carbon-neutral growth" at 2020 levels of emissions, with the baseline set to be the average of 2019 and 2020 emissions. Subsequently, as a result of the COVID-19 pandemic and its enormous impact on travel demand and emissions, it was decided to use 100% of 2019 CO_2 emissions from international civil aviation as the baseline for the Pilot phase. The First phase of the Offset scheme, which began in 2024, saw the baseline reduced to 85% of the 2019 CO_2 emissions from international civil aviation activities. In essence, aeroplane operators who fall within the CORSIA scope are required to offset more emissions above the new baseline. Currently, there is no discussion on making further changes to the CORSIA baseline in the near future.

Based on the reported annual international flight emissions from the MRV system, the participating Member States in the Offsetting system are responsible for calculating the amount of offset required from aeroplane operators. The offsetting calculation formulae are introduced in Table 3. It should be noted that only CO_2 emissions from international flights are accounted in the formulae.

The calculation methodology for aeroplane operators offsetting requirements is expected to evolve over time to reflect a progressive tightening of the emissions reduction obligation, as summarised in Table 4. The general implication will see more aeroplane operators offsetting a greater portion of their emissions by adjusting the baseline emissions. Furthermore, factoring the sectoral component, the overall increase in CO_2 emissions from the international aviation sector, into individual operators offsetting requirements ensure operators collectively share the burden of offsetting the overall increase in international aviation emissions. With the initiative to factor in individual operators' emissions growth in their offsetting requirement, it adds further accountability for higher emitting operators to incentivise better emissions management.

Table 3: CORSIA offsetting scheme calculation formulae 2021-2035

Description	Formula	Explanations
Aeroplane operators' offsetting requirement formula (2021-2023)	$OR_y = OE \times SGF_y$	Calculate aeroplane operators' CO_2 emissions offset in the reporting year by Member States participating in the Pilot phase of the offset scheme from 2021 to 2023 OR_y Aeroplane operators' offsetting requirements in Year y OE Aeroplane operators' CO_2 emissions covered by CORSIA in the Year 2019 SGF_y Sector growth factor in year y.

[4] Revenue Tonne Kilometres (RTKs) is the utilised (or sold) capacity for passengers and cargo expressed in metric tonnes, multiplied by the distance flown. In essence, RTK measures the volume of air transport activity

[5] CORSIA Eligible Emissions Units https://www.icao.int/environmental-protection/corsia/pages/corsia-emissions-units.aspx

Description	Formula	Explanations
Aeroplane operators' offsetting requirement formula (2024-2035)	$OR_y = \%S_y \times (OE_y \times SGF_y) + \%O_y \times (OE_y \times OGF_y)$	Calculate aeroplane operators' CO_2 emissions offset in the reporting year by Member States participating in the First and Second phase of the offset scheme from 2024 to 2035 OR_y Aeroplane operators' offsetting requirements in Year y OE_y Aeroplane operators' CO_2 emissions covered by CORSIA in the Year 2019 $\%S_y$ Sectoral per cent in the given year y $\%O_y$ Individual per cent in the given year y SGF_y Sector growth factor in year y. OGF_y Aeroplane operator's growth factor
Sector growth factor formula (2021-2023)	$SGF_y = \frac{(SE_y - SE_{B,y})}{SE_y}$	Announced by ICAO every year based on the reported CO_2 emissions from States SE_y Total sectoral CO_2 emissions in year y $SE_{B,y}$ Total annual sectoral CO_2 emissions in Year 2019 covered by the applicability of offset requirement in year y
Sector growth factor formula (2024-2035)	$SGF_y = \frac{(SE_y - SE_{B,y})}{SE_y}$	Announced by ICAO every year based on the reported CO_2 emissions from States SE_y Total sectoral CO_2 emissions in year y $SE_{B,y}$ 85% of the total annual sectoral CO_2 emissions in Year 2019 covered by the applicability of offset requirement in year y
Aeroplane operator's growth factor	$OGF_y = \frac{(OE_y - OE_{B,y})}{OE_y}$	Calculate the individual aeroplane operator's CO_2 emissions growth compared to its own baseline figure OGF_y Aeroplane operator's growth factor OE_y Total aeroplane operators' CO_2 emissions in the given year $OE_{B,y}$ 85% of the total annual aeroplane operator's CO_2 emissions in the Year 2019

Source: ICAO Doc 9501 — Environmental Technical Manual, Volume IV 3

Table 4: Summary of increasing ambition to the CORSIA offsetting calculations 2021-2035

Reporting periods	Summary of changes
2021 – 2023	100% of the aeroplane operators' baseline CO_2 emissions in the Year 2019 is accounted in OE

Reporting periods	Summary of changes
2024 – 2026, 2027 – 2029, 2030 – 2032	**Reduced CO_2 baseline**: The baseline has reduced from 100% to 85% of the aeroplane operators' CO_2 emissions from international flights in the year 2019 in OE_y **Take sectoral growth into account**: During the specified reporting period, $\%S_y$ will be 100%, such that all aeroplane operators collectively share the burden of offsetting the overall increase in CO_2 emissions from international aviation sector captured by the sector growth formula SGF_y
2033 – 2035	**Reduce sectoral growth share and factor in operators own emissions growth**: During the specified reporting period, $\%S_y$ will be reduced from 100% to 85%, the remaining 15% is allocated to $\%O_y$ to capture the aeroplane operators' emissions growth in OGF_y

Source: Ricardo interpretation, ICAO Doc 9501 — Environmental Technical Manual, Volume IV 3

Table 5: Scope comparison of CORSIA MRV and Offsetting system

MRV scope
Aeroplane operator produces > 10,000 tCO_2 annually from international flights ● Since 1 January 2019 ● Use an aeroplane with a maximum certified take-off mass of > 5,700 kg State, humanitarian, medical and firefighting operations are exempted
Offsetting scope
Pilot phase (2021-2023) and First phase (2024-2026): Aeroplane operator produces > 500,000 tCO_2 annually from international flights ● Use an aeroplane with a maximum certified take-off mass of > 5,700 kg ● Between States that decide to participate in the Offsetting scheme voluntarily State, humanitarian, medical and firefighting operations are exempted **Second phase (2027-2035):** Mandatory participation for States and their registered aeroplane operators falls into one of the following categories: ● States with their international aviation activities recording greater than 0.5% of the global RTK measured in Year 2018 ● States that collectively account for 90% of total international aviation activity (measured by RTKs) must participate, except for Least Developed Countries, Small Island Developing States, and Landlocked Developing Countries State, humanitarian, medical and firefighting operations are exempted

Source: Ricardo interpretation, ICAO Doc 9501 — Environmental Technical Manual, Volume IV 3

1.1.3 CORSIA Eligible Fuels

Aeroplane operators can choose to purchase CORSIA-eligible fuels for their international flight operations during the reporting period to reduce their CO_2 emissions offsetting requirements.

Based on the pilot phase offsetting system, certified CORSIA eligible fuels are required to meet the following requirements:

- Produced by fuel producers certified under an approved Sustainability Certification Scheme developed by ICAO.

- The CORSIA eligible fuels must meet the CORSIA Sustainability Criteria, one of the requirements includes achieving at least a 10% reduction of greenhouse gas emissions compared to the baseline aviation fuel on a life cycle basis.

The life cycle emissions calculation for aviation fuels considered for the accreditation scheme takes account of both the core life cycle assessment (LCA) emissions and the induced land use change (ILUC) emissions of the fuel.

Apart from the greenhouse gas percentage reduction requirement, the CORSIA Sustainability Criteria also stipulated that the eligible fuels should not be made from biomass obtained from land with high carbon stock. The definition of CORSIA eligible fuels criteria for the current offsetting period was updated in November 2022[6]. The update further distinguishes CORSIA eligible fuels into two categories: CORSIA Sustainable Aviation Fuel (SAF) and CORSIA Lower Carbon Aviation Fuel (LCAF). Both SAF and LCAF are eligible to claim emissions offsetting under the current phase from 2024 to 2026. The CORSIA SAF criteria retain the original CORSIA eligible fuel requirements with additional environmental, natural resources, and human rights requirements added. The CORSIA LCAF criteria are currently under development at the time of writing.

Emissions reduction claims from the use of CORSIA Eligible Fuels should be based on the mass of CORSIA Eligible Fuels according to purchasing and blending records, but only for fuels used directly on international flights; resold and transferred eligible fuels are not qualified for emissions reduction claims. Aeroplane operators should claim the verified reduction of their emissions associated with CORSIA Eligible Fuels use to the State, which will take the reduction into account when calculating the final offsetting requirement during the compliance period.

As of January 2024, 126 ICAO Member States have committed to participate voluntarily in the offsetting activities under the First Phase of CORSIA.

1.2 EU ETS

The European Union Emissions Trading System (EU ETS) is a critical component of the EU's climate policy to reduce greenhouse gas emissions. The scheme was first launched in 2005 and expanded its coverage to different economic sectors, including civil aviation, in 2012. The EU ETS operates on a cap-and-trade principle, using a market-based approach to reduce overall CO_2 emissions by providing economic incentives. See Box 1 for more details about the concept of a cap-and-trade emissions scheme. The European Commission is responsible for policymaking and management of the overall ETS scheme, with national authorities responsible for the enforcement component. Since EU ETS for aviation applies to both EU (or EEA) and non-EU aeroplane operators, Member States with the greatest estimated attributed aviation emissions from flights performed by the individual non-EU aeroplane operator in the monitoring year are responsible for administering enforcement, on top of EU aeroplane operators registered with them.

When EU ETS was first proposed in 2012, its geographical coverage included international flights between EEA Member States[7] and third countries (extra-EEA flights), but this was opposed by key EU trading partners, including the US and China threaten to take legal and economic measures against the policy[8], leading to the EU's decision to suspend its application to extra-EEA flights and limit its scope to the current form[8] (intra-EEA flights, including international flights between EEA Member States). Currently, CORSIA applies to extra-European flights from the EEA to CORSIA participating countries. The current geographical coverage of EU ETS for aviation only applies to intra-EEA flights plus departing flights from the EEA to

[6] CORSIA Sustainability Criteria for CORSIA Eligible Fuels https://www.icao.int/environmental-protection/CORSIA/Documents/ICAO%20document%2005%20-%20Sustainability%20Criteria%20-%20November%202021.pdf

[7] European Economic Area (EEA) consists of EU Member States plus Iceland, Liechtenstein and Norway.

[8] Aviation's contribution to European Union climate action: Revision of EU ETS as regards aviation https://www.europarl.europa.eu/RegData/etudes/BRIE/2022/698882/EPRS_BRI(2022)698882_EN.pdf

Switzerland from 2020[9] and to the UK from 2021[10]. From January 2024[11], the following exemptions apply to outermost regions[12]:

- Flights between an outermost region of a Member State and the same Member State outside that outermost region,
- Flights within same outermost region,
- Flights between different outermost regions in the same Member State.

This means that non-domestic flights to and from outermost regions are covered by the EU ETS from January 2024.

Most aeroplane operators operating commercial flights within the geographical coverage of EU ETS for aviation, regardless of their registration location, are subject to the 'ETS compliance cycle', involving procedure of monitoring, reporting and verification (MRV), together with all the associated processes emissions on an annual basis. Flights that are exempted from the EU ETS for aviation include military, customs and police, humanitarian, firefighting, search and rescue, and emergency medical flights. Flights performed exclusively for the purpose of scientific research, and flight checks are also exempted from the ETS[13].

1.2.1 Monitoring, reporting and verification (MRV)

Similar to the MRV procedures in CORSIA, most aeroplane operators under the scope of EU ETS for aviation are required to submit an annual Monitoring Plan, detailing the monitoring methodology the aeroplane operators use to calculate their CO_2 emissions. Member States are responsible for the approval of the Monitoring Plan. **The ETS Monitoring Plan shares a similar function to the CORSIA MRV EMP** to ensure consistent, approved methodologies by ICAO are applied to tracking CO_2 emissions from flights. The Monitoring Plan should include one of the two approved fuel consumption monitoring methodologies by the European Commission, aircraft fleet information, data management and control, and assignment of responsibilities assigned and managed at the organisation level. **The European Commission only approved two methods to monitor fuel consumption compared to the five methods approved by CORSIA. The Commission-approved methods track the fuel levels before and after the flight plus the amount of fuel uplifted, which share a similar methodology to the CORSIA equivalent.**

Small emitters meeting either one of the following criteria can submit a simplified Monitoring Plan and can apply for a simplified monitoring procedure to estimate their fuel consumption using a small emitters tool developed by Eurocontrol:

- Emit less than 25,000 tCO_2 per year.
- Operate fewer than 243 flights per period for three consecutive four-month periods.

The fuel consumption estimation tool developed by Eurocontrol requires flight operation information including aircraft type and flight distance to calculate the estimated fuel use, which **differs from the CORSIA equivalent** that estimates the CO_2 emissions directly from the supplied flight operation information.

For aeroplane operators not qualified as small emitters, the full annual 'ETS compliance cycle' applies, involving aeroplane operators, national authorities, and accredited verifiers as shown in Figure 2. The compliance cycle requires the aeroplane operator to produce an Annual Emissions Report, using the methodology stated in their Monitoring Plan that has been approved by national authorities.

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[9] Linking the Swiss and EU emissions trading systems https://www.bafu.admin.ch/bafu/en/home/topics/climate/info-specialists/reduction-measures/ets/linking-swiss-eu.html

[10] The impact of Brexit on the EU Emissions Trading System for aviation https://climate.ec.europa.eu/system/files/2021-09/policy_transport_aviation_faq_aviation_brexit_en.pdf

[11] Before January 2024, flights to/from outermost regions and EEA countries were excluded, while flights within outermost regions were included

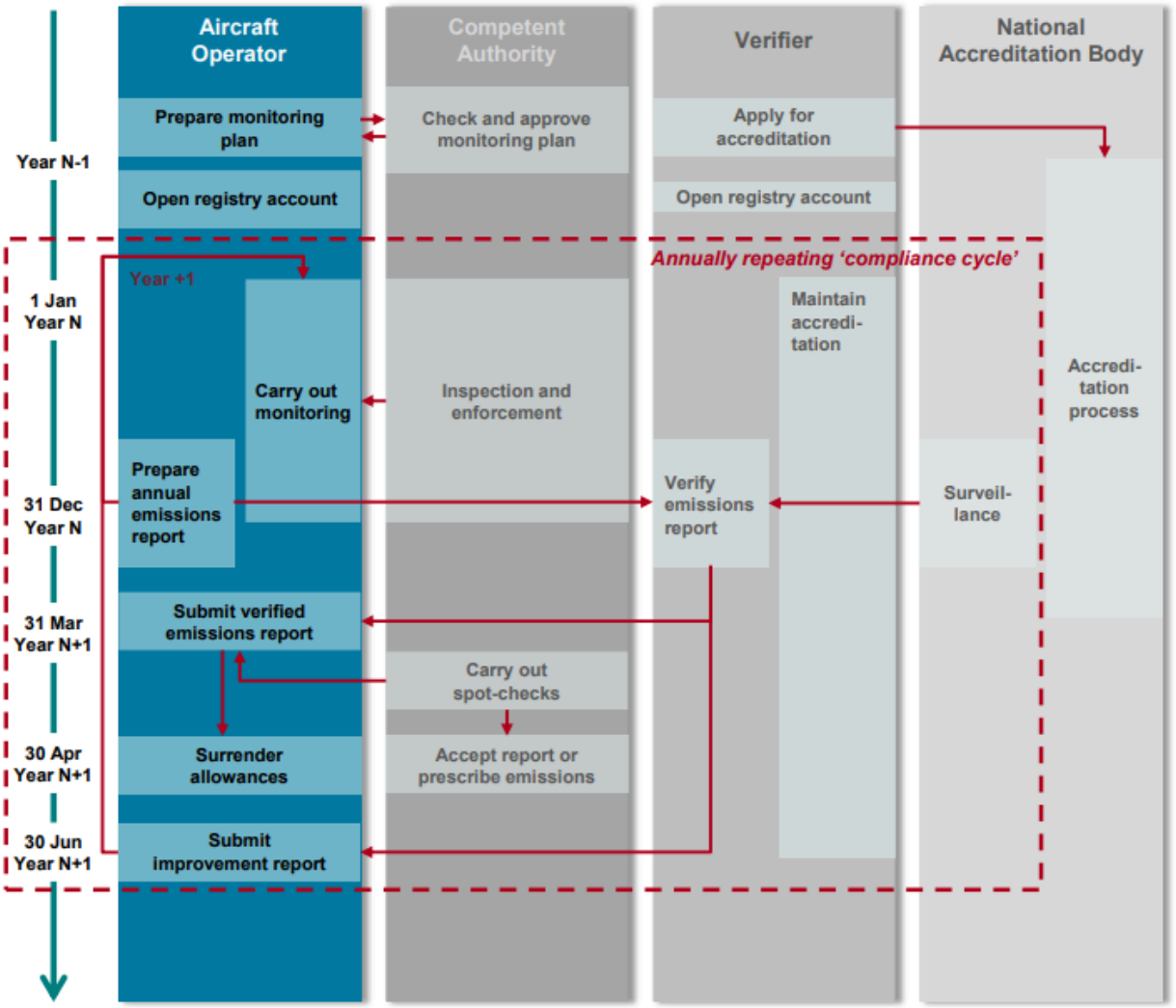
[12] These regions are Canary Island, French Guiana, Guadeloupe, Martinique, Mayotte, Réunion, Saint-Martin, Azores and Madeira

[13] Commission Decision of 8 June 2009 on the detailed interpretation of the aviation activities listed in Annex I to Directive 2003/87/EC of the European Parliament and of the Council https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32009D0450

The verification of the Annual Emissions Report, which involves seeking external verification from accredited bodies approved by national authority, applies to all aeroplane operators except for small emitters reporting with the small emitters tool[14]. For the verification, external accredited verifiers are responsible for verifying the report produced by aeroplane operators and produce an Improvement Report highlighting outstanding non-conformities or recommendations for improvement to the operator. **Unlike CORSIA, accredited verifiers are not required to submit a separate verification report to the national authority**. However, aeroplane operators are obliged to submit an Improvement Report to the national authorities.

Upcoming changes to the MRV requirement following a legislative update in 2023 have included the reporting of non-CO_2 aviation effects from the reporting year 2025[15]. Non-CO_2 aviation effects refer to the climate effects of nitrogen oxides (NOx), soot particles, oxidised sulphur species, and water vapour, including contrails, released during fuel combustion. The current regulation states that operators should include a minimum of three-dimensional aircraft trajectory data, ambient humidity, and temperature on top of the current MRV requirements to calculate a CO_2 equivalent per flight for the non-CO_2 aviation effects.

Figure 2: Stakeholder relationships under EU ETS for aviation



[14] Reported small emitters' emissions using the tool are regarded as verified emissions

[15] Directive (EU) 2023/958 of the European Parliament and of the Council of 10 May 2023 amending Directive 2003/87/EC as regards aviation's contribution to the Union's economy-wide emission reduction target and the appropriate implementation of a global market-based measure https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32023L0958

Source: EU ETS Monitoring and Reporting – Quick guide for aircraft operators[16]

1.2.2 Auctioning and surrendering allowances

Identical to the EU ETS MRV scope, both commercial and non-commercial aviation operators, albeit with different CO_2 emissions thresholds, subject to the MRV requirements are also obliged to participate in the cap-and-trade system in the EU ETS for aviation. This differs from the CORSIA approach, where the scheme only covers commercial aviation operators.

Aeroplane operators can purchase two types of emissions allowances – EU Aviation Allowances (EUAA) and EU Allowances (EUA) acquired from other sectors to meet their ETS obligations. EUA can be used by all EU ETS covered sectors while EUAA are specifically designed for and used by aeroplane operators. The possibility to use both EUA and EUAA allow aeroplane operators to use their allowance with more flexibility.

From 2013 to 2020, the annual cap on aviation allowances for EU ETS was fixed at 95% of the annual average intra-EEA aviation emissions from 2004 to 2006. During this period, it is reported that only 15% of the EUAA were auctioned, with 82% of the allowances granted for free to aeroplane operators and 3% reserved for new and fast-growing operators[17]. Since 2021, a linear reduction factor was applied to the aviation allowance cap at a rate of 2.2% annually, with the reduction rate increased to 4.3% from 2024 to 2027, and 4.4% from 2028 onwards[18]. The latest data on total EUAA in 2024 is 28,866,578 units, where one unit corresponds to one tonne of CO_2 emissions. The increasingly progressive reduction in the aviation sector maximum emissions cap reflects the European Commission's ambition to decarbonise the aviation sector, and further internalise the emissions costs through the auctioning of increasingly scarce allowances.

In terms of revenue allocation of the auctioned allowance, Member States are responsible for auctioning EUA and EUAA on a common auction platform agreed and jointly procured by Member States. Member States get to decide how to use the income from auctioned allowances for climate, energy and social purposes. The revenue generated from auctioning ETS allowances across all participating sectors has reached €38.8 billion in 2022. The revenue is expected to grow due to the expected increase in allowance auction prices. It is expected that the phase out of free EUAA allowance combined with the linear total emission cap reduction will push up the unit cost of EUAA. Under the current rules, Member States should allocate 100% of the EUA and EUAA auctioning revenue towards climate actions.

Regarding auction rules and regulations, these are clearly set out by the European Commission in a delegated act Regulation (EU) 2023/2830, covering the design of the auction, entities eligible to access the auctions, procedures for cancelling allowances, payments and delivery of the allowances[19]. Additionally, Member States are responsible for deciding the allocation of free allowances to each aeroplane operator. To be eligible for the free allowance application, operators are required to submit their tonne-kilometre data for flights within the ETS scope. The tonne-kilometre data is also subject to verification by an external accredited verifier. For Member States, the decision regarding free allowance allocation takes the operators' efficiency in transporting passengers and cargo, measured by the number of tonne-kilometres flown.

The latest Directive 2023/958 announced in 2023 updated the EU ETS for aviation to accelerate the implementation of the polluter-pays principle by gradually phrasing out free allowances. Free allowances to aeroplane operators will reduce progressively by 25% and 50% in 2024 and 2025 respectively, leading to the ultimate elimination of free allowances after 2026[20]. The combined effect of reducing the overall emissions

[16] EU ETS Monitoring and Reporting – Quick guide for aircraft operators https://climate.ec.europa.eu/document/download/c91e0e7a-99b4-4ba7-81f3-e7dc5c1a15aa_en?filename=quick_guide_ao_en.pdf

[17] Allocation to the aviation sector https://climate.ec.europa.eu/eu-action/eu-emissions-trading-system-eu-ets/free-allocation/allocation-aviation-sector_en

[18] Adoption of the Commission Decision on the total quantity of allowances to be allocated in respect of aircraft operators in the EU ETS for 2024 https://climate.ec.europa.eu/news-your-voice/news/commission-decides-2024-allowances-aircraft-operators-2023-10-31_en

[19] Commission Delegated Regulation (EU) 2023/2830 of 17 October 2023 supplementing Directive 2003/87/EC of the European Parliament and of the Council by laying down rules on the timing, administration and other aspects of auctioning of greenhouse gas emission allowances https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex:32023R2830

[20] Directive (EU) 2023/958 of the European Parliament and of the Council of 10 May 2023 https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32023L0958

cap and the cancellation of free allowances is likely to increase aeroplane operators' compliance cost, further incentivising more efficient emissions management and investments in technology and more fuel-efficient aircraft fleet.

If aeroplane operators underestimated their emissions allowance without sufficient allowance to cancel out the exceedance, a penalty is applied at the current price equivalent to €100 in 2012 per exceeded tonne of CO_2, on top of the cost of surrendering allowance due. The names of the offending operators will be disclosed to the public.

In terms of non-CO_2 aviation effects, both the current EU ETS cap-and-trade system and the CORSIA offsetting system do not take it into account. Following the 2023 update on the EU ETS regulation requiring aeroplane operators to monitor their non-CO_2 aviation impacts as mentioned earlier, the European Commission plans to collate the information and propose new legislations to mitigate non-CO_2 aviation effects by extending the cap-and-trade scope before 2028.

1.2.3 EU ETS sustainable aviation fuels (SAF) criteria

Like CORSIA, aeroplane operators can reduce their emissions in ETS by adopting a greater share of sustainable aviation fuels to their flights subject to EU ETS for aviation. Regarding the fuels criteria, the EU ETS adopts a separate set of sustainability criteria for fuels to be labelled as SAF, covering drop-in aviation fuels compliant with the sustainability criteria of the Renewable Energy Directive (RED). The SAF, as defined in ReFuelEU Aviation Regulation, are eligible for ETS emissions reduction claim[21]:

- Synthetic aviation fuels
- Aviation biofuels
- Recycled carbon aviation fuels

According to the European Union Aviation Safety Agency, SAF that is certified as compliant with the sustainability criteria of the RED will be counted as zero emission under the EU ETS scheme, reducing the operators' reported emissions and compliance cost to purchase emission allowances[22]. Aeroplane operators should use their fuel purchase records and documents provided by fuel suppliers to verify the SAF biomass fraction and carbon content, which will be reviewed by the national authorities to determine the eligibility to claim emissions reduction.

Directive 2023/958 also reserved 20 million allowances available for aeroplane operators that use sustainable aviation fuels from 2024 to 2030, to cover 50-100% of the price differential between fossil fuel-derived and non-fossil fuel-derived aviation fuels depending on the fuel pathways and fuel uptake locations. This measure helps narrow the cost gap between SAF and fossil fuel-derived aviation fuels, rewarding the greenest SAF accordingly, which is estimated to cost the industry €3.6 billion from now to 2030 without this mechanism[23]

It is also suggested that the next revision of EU ETS for aviation in 2026 might reconsider the scope of application after assessing both the EU ETS and CORSIA implementation, as mentioned in later sections of this report[24].

[21] ReFuelEU Aviation https://transport.ec.europa.eu/transport-modes/air/environment/refueleu-aviation_en

[22] Sustainable Aviation Fuels https://www.easa.europa.eu/en/domains/environment/sustainable-aviation-fuels-saf#

[23] Revisions to the EU ETS set a global model for sustainable aviation fuel investment https://theicct.org/revisions-to-the-eu-ets-set-a-global-model-for-saf-investment-apr24/

[24] Updates on CORSIA and the 2023 revised EU Emissions Trading System (ETS) for aviation https://www.ecac-ceac.org/news/1013-updates-on-corsia-and-the-2023-revised-eu-emissions-trading-system-ets-for-aviation

2. Expected CORSIA developments

2.1 Participating states under CORSIA

Of the 193 Member States of ICAO, 154 were recognised as having a share of international aviation revenue tonne-kilometres (RTK) in 2018, the base year for the identification of the requirements for states to participate in CORSIA[25]. The total RTK in that year was approximately 736 billion tonne-kilometres.

Of the 154 states with international RTK in 2018, 36 states had more than a 0.5% share, the threshold for mandatory participation in the offsetting activities under CORSIA from 2027[26]. These states had a total of 664 billion tonne-kilometres of international aviation, approximately 90% of the global total. However, of the 36 highest ranked states, two were classified as developing states[27], removing their requirement for mandatory participation. The remaining 34 countries had a total of 87% of the global total RTK.

As of October 2023, 126 states had committed to participating voluntarily in the First Phase of CORSIA from 1 January 2024[28]. This includes 30 (out of 36) states for whom participation will be mandatory from 2027, 73 (out of 118) states with international RTK reported in 2018 but for whom participation will still be voluntary from 2027, and 23 (out of 39) states with no international RTK reported in 2018.

Each year since 2021, ICAO has reported the names of states that have indicated their intention to participate voluntarily in CORSIA from the following year. The reports in 2021 added 19 states to those that had committed previously, in 2022 8 states were added, while in 2023 a further 11 states were added to the list. While it is unlikely that the rate of addition of states to the list will be maintained in the next few years (as the number of non-participating states continues to reduce), it is likely that there will be some new additions. In most cases, the additional states are likely to have a relatively small share of international aviation (as the majority of states with more than 0.5% of the total are already participating). However, as the requirements for offsetting emissions are based on those flights between two participating states, the increase in the emissions captured under CORSIA may be larger than the share of emissions of the new states (as the flights from already participating states to the newly participating states will be included, as well as the flights from the newly participating states).

From 2027, in principle, all the 34 highest ranked (in RTK in 2018) states that are not developing states will be required to participate in CORSIA on a mandatory basis. Of these 34 states, 29 are already participating voluntarily, and it would not be expected that they would raise any problems with continuing to participate. Of the two developing states with more than 0.5% of international RTK in 2018, Singapore is already participating voluntarily, while Ethiopia is not.

The five major states that are not currently participating are China, the Russian Federation, India, Brazil and Vietnam.

Table 6: Statements made by five major states regarding their non-participation in CORSIA pilot and first phases

State	Statements made
Brazil	In October 2022, Brazil confirmed that they would participate in CORSIA from 2027[29].

[25] 2018 International Total RTK, https://www.icao.int/sustainability/Documents/RTK%20ranking/International%20RTK%20rankings_2018_SIDS_LDC_LLDC.pdf

[26] In addition to the 0.5% of total RTK in 2018 threshold, CORSIA also includes a threshold at 90% of cumulative RTK when countries are ranked in descending order of their share of total RTK. The 36th country in the list, Portugal, falls outside this threshold, but had a share of total RTK in 2018 above the 0.5% threshold, so is included in the list of those that must participate from 2027.

[27] Singapore (ranked 13) is classified as a Small Island Developing State (SIDS) and Ethiopia (ranked 24) is classified as both a Least Developed Country (LDC) and a Landlocked Developing Country (LLDC).

[28] CORSIA States for Chapter 3 State Pairs, https://www.icao.int/environmental-protection/CORSIA/Documents/CORSIA%20States%20for%20Chapter%203%20State%20Pairs_4Ed_rev_web.pdf

[29] https://www.gov.br/anac/en/news/2022/brazil-signs-commitment-for-sustainable-aviation-with-icao

State	Statements made
	Brazil also noted that their aeroplane operators would compensate (offset) proportionally to their emissions on international flights, not their level of growth (so reducing the burden on growing smaller operators).
China	In October 2019, China expressed reservations to ICAO regarding the adoption of CORSIA[30]. Their main concern centred on the impacts on the rapidly growing Chinese aviation sector and how the scheme should reflect the UNFCCC principle of Common but Differentiated Responsibilities.
India	In November 2019, India expressed its reservations regarding the adoption of CORSIA[31]. It expressed a view that the offsetting requirements under CORSIA should be related to international travel by nationals of the Member State, rather than the flights by Member States' aeroplane operators. India also expressed concerns on the impacts of CORSIA on the rapidly growing Indian aviation sector, with significant growth expected in the sector between 2020 and 2027.
Russian Federation	At the ICAO Assembly in August 2019, Russia, jointly with China, presented a working paper (WP/306) expressing their views on the implementation of CORSIA[32]. They indicated that they felt that the goals and design of CORSIA lacked "moral fairness".
Vietnam	No statement identified in the public domain.

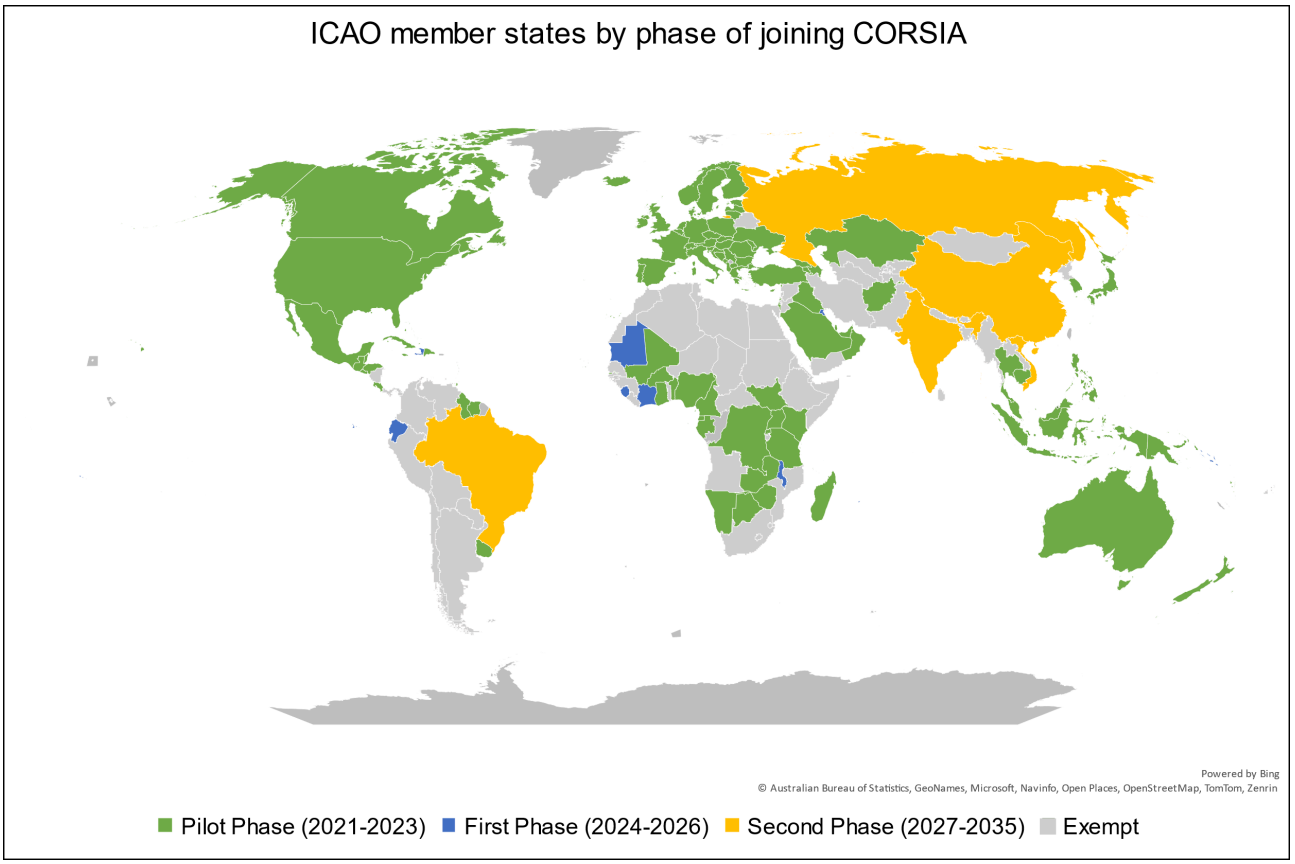
In principle, participation in offsetting activities under CORSIA is mandatory for all ICAO Member States, other than those exempted for the reasons described above, from 2027. As confirmed by consultation with independent sector experts, a Member State may file a difference to ICAO, indicating that it will not implement a "mandatory" regulation (such as participation in CORSIA); however, to date, none of the above have done so. Therefore, it is reasonable to assume that the five states in Table 6 may participate in offsetting activities in the second phase from 2027.

[30] https://www.icao.int/Meetings/a40/Documents/Resolutions/china_EN.pdf

[31] https://www.icao.int/Meetings/a40/Documents/Resolutions/India_EN.pdf

[32] https://www.icao.int/Meetings/A40/Documents/WP/wp_306_en.pdf

Figure 3: Map of states participation in CORSIA offsetting activities



Source: Ricardo analysis based on CORSIA central registry data

Since 2021, ICAO has required all Member States to report their emissions on international flights, and has published those emissions (by country pair) through the CORSIA Central Registry[33]. Based on the emissions reported for 2022, the 126 Member States that have committed to participating in CORSIA from 2024 account for 66.0% of global CO_2 emissions (on international flights between two participating states as a percentage of all international flights for which emissions are reported). If the five extra major states in Table 6 are added to the list of participating states, the percentage rises to 85.4%.

2.2 Other potential scheme design changes

ICAO Assembly Resolution A40-19 included a requirement that the ICAO Council should conduct a periodic review of CORSIA every three years, starting in 2022.

The 2022 review[34] identified the impacts that the COVID-19 pandemic had on emissions in 2020 to 2022, and the potential impacts on future offsetting requirements if the original baseline of the average of 2019 and 2020 emissions was retained. This led to the decision to use only 2019 emissions for the baseline during the pilot phase, to use 85% of 2019 emissions as the baseline during subsequent phases. ICAO also made some changes to the planned timelines for the transition from a sectoral-only approach to calculating offset requirements to one that takes account of the individual aeroplane operator's growth in emissions.

The 2022 review also considered the costs to aeroplane operators from the MRV and offsetting requirements of CORSIA and possible market distortions that might arise.

The next periodic review of CORSIA is due in 2025.

[33] https://www.icao.int/environmental-protection/CORSIA/Pages/CCR.aspx

[34] https://www.icao.int/environmental-protection/CORSIA/Pages/CORSIA-and-Covid-19.aspx

In a paper to the 2023 CAEP Steering Group meeting[35], the United States noted that two options had been presented by CAEP Working Group 4 for the calculation of emissions to be offset by new aeroplane operators under CORSIA; either to use actual emissions from their flights (from their second year of operation) or to base their offsetting requirements on a 100% sectoral approach (even after established operators use a 85% sectoral and 15% individual emissions approach).. The United States noted that they had seen several new entrant operators appear in recent years and expected the trend to continue; they expressed the view that those new entrant operators should not be treated differently from other operators with regard to CORSIA and, therefore, that the option based on their actual emissions should be selected. This could be an area for future developments for CORSIA as the offsetting approach (for established operators) moves from 100% sectoral to one including the individual operator emissions.

As noted above, some countries have expressed reservations regarding the implementation of CORSIA. These reservations were re-expressed at the 41st ICAO Assembly in October 2022[36] by China, Russia and Eritrea, with a particular focus on the impacts of CORSIA on states with rapidly growing aviation sectors. Although no formal proposals have been made for changes to the design of CORSIA in response to these concerns, the perceived "unfairness" of the scheme towards such states could be used as an argument for changes, particularly regarding how to treat states with such high growth rates. Conversely, the revisions to the EU ETS (particularly the phase out of free allowances and the increased rate of reduction to the emissions cap) indicate concerns that more needs to be done to reduce emissions from the aviation sector. If other states share those concerns, CORSIA could be reformed to strengthen its environmental effects, for example by further reducing the baseline emissions (currently 85% of 2019 levels) for the second phase from 2027. Again, no proposals have been made for changes to CORSIA in line with these concerns.

3. COVERAGE OF GHG EMISSIONS UNDER CORSIA AND EU ETS

This section compares GHG emissions coverage in CORSIA and EU ETS. First, we consider CO_2 emissions that are subject to CORSIA offsetting and EU ETS obligations (i.e. flights between participating countries and non-exempted). Second, we analyse the proportion of CO_2 emissions that are subject to a carbon price either in the form of carbon offsets or EU ETS allowances to be purchased by operators. The analysis indicates that the proportion of emissions subject to carbon price is substantially higher in the EU ETS compared to CORSIA. Finally, we analyse the significance of non-CO_2 emissions and expected coverage under both schemes.

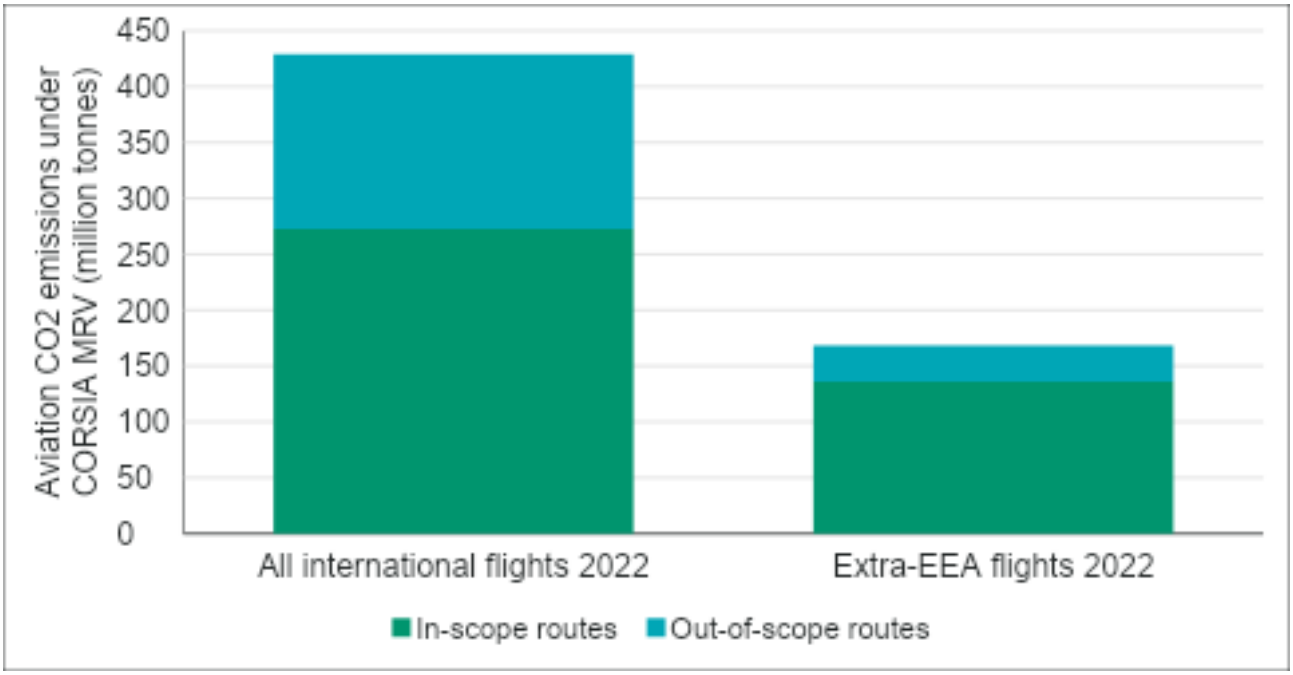
3.1 CORSIA CO_2 EMISSIONS

CO_2 emissions from routes under the CORSIA offsetting scheme are those under the CORSIA MRV which are generated in flights between two participating countries. Figure 4 presents CO_2 emissions from country pairs subject to CORSIA offsetting requirements as of 2022 (107 out of 193 Members States, i.e. those that are non-exempt and have joined the voluntary phase by 2022) and compares them with total CO_2 emissions reported under MRV. We have estimated the share of emissions from in-scope routes in 2022 for all international flights and for international extra-EEA flights (i.e. international flights to or from EEA countries, excluding flights between EEA countries). This shows a higher proportion of emissions from in-scope routes when considering international extra-EEA flights only.

[35] https://icao.usmission.gov/wp-content/uploads/sites/280/CAEPSG.20232.WP_.046.4.en_.pdf

[36] https://www.icao.int/Meetings/a41/Pages/assembly-report-and-minutes.aspx

Figure 4: CO_2 emissions from routes under CORSIA offsetting scheme and total emissions reported under CORSIA MRV in 2022



Source: Ricardo analysis based on CORSIA central registry data

Considering the expected participation of countries in upcoming CORSIA phases (see section 2 for more details), we have projected the share of emissions from in-scope routes in 2024-2026 and in 2027-2035 (see Table 7). Additional emissions coverage is expected to be marginal in 2024. Conversely, the amount of emissions subject to offsetting requirements may grow significantly from 2027 under the assumption that all non-exempt countries will effectively implement the scheme from 2027 (see more details on potential options in Section 2).

Table 7: Projected share of CO_2 emissions from in-scope routes in upcoming CORSIA phases, compared to 2022 levels

	2022	2024-2026	2027-2035
All international flights	63%	66%	84%
Extra-EEA flights	81%	83%	91%

Source: Ricardo analysis based on CORSIA central registry data

Note: Shares for 2024 and 2027 assume 2022 emissions levels per country pair and include countries as per expected join date. Projections for 2027-2035 assume that all non-exempt countries effectively implement the scheme

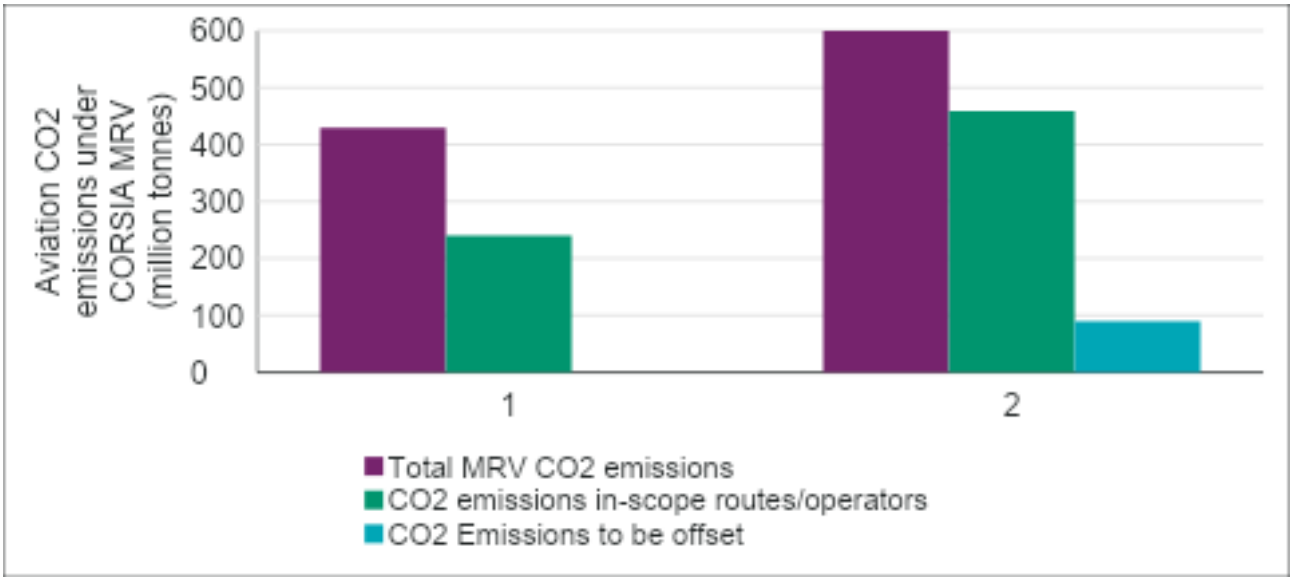
Additional exemptions to CORSIA offsetting requirements apply to operators with annual emissions below 500,000 tCO_2 (see Table 5). **CO_2 emissions from in-scope operators** (i.e. annual emissions higher than 500,000 tCO_2) represent 88% of total emissions reported by all operators.[37]

CO_2 emissions to be offset by operators are those in excess of the defined baseline, as per calculations in Table 3. In 2022, CO_2 emissions from in-scope routes were still lower than the CORSIA baseline at the time (100% of 2019 emissions), which means that operators did not have to offset any emissions. With the revised baseline from 2024 (85% of 2019 emissions), operators will need to start acquiring eligible carbon credits as soon as emissions from in-scope routes exceed the new baseline. In Figure 5, we have extracted

[37] Calculation based on CORSIA central registry data for 2022. The proportion was also calculated for emissions from in-scope routes in 2022 only with very similar results (90%)

recent projections of international aviation CO_2 emissions from ICAO[38] to estimate emissions to be offset by 2030. This shows that total emissions to be offset in 2030 may represent 20% of total emissions from in-scope routes/operators and 15% of total MRV emissions.

Figure 5: Total CO_2 emissions from routes/operators under CORSIA offsetting scheme and CO_2 emissions to be offset by operators in 2022 and 2030, compared to total CO_2 emissions under MRV



Source: Ricardo analysis

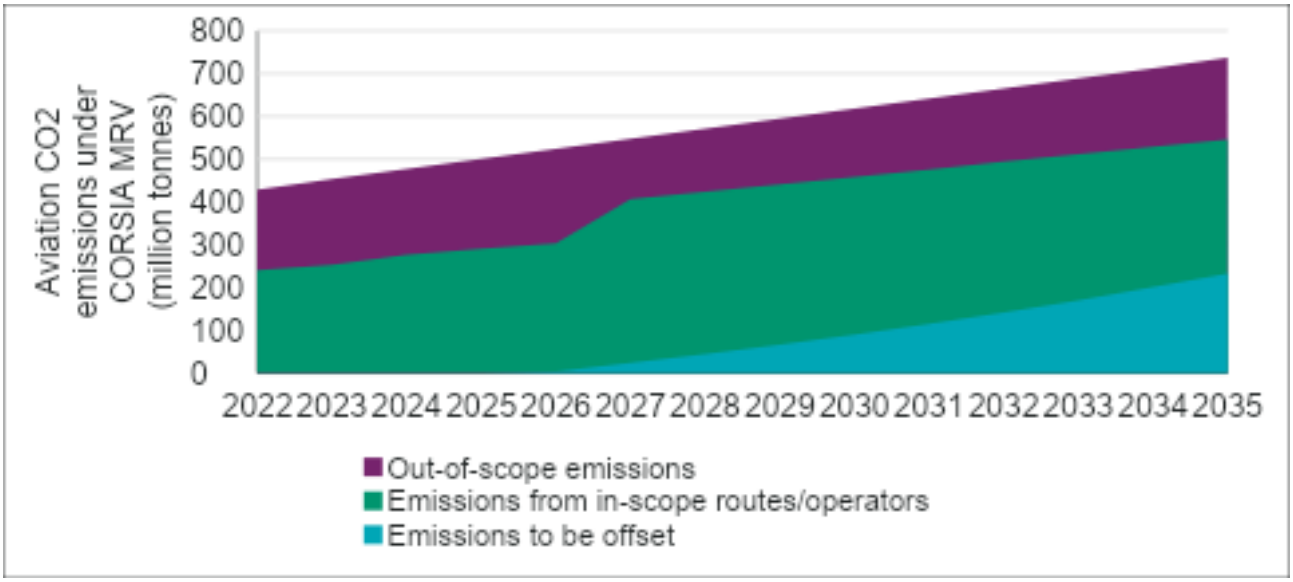
Note 1: Projections of CO_2 emissions by 2030 are based on ICAO's Report on the Feasibility of a Long-Term Aspirational Goal, Integrated scenario 1, which represents current expectation of future available technologies, operational efficiencies, and fuel availability

Note 2: Emissions from in-scope routes/operators are calculated by applying share of emissions from in-scope operators to emissions from in-scope routes

Figure 6 shows the full projection of CO_2 emissions under CORSIA for the period 2022-2035, by linearly interpolating expected emissions growth from 2022 to 2030. This suggests that operators would need to acquire offsets from 2026 only.

[38] ICAO's Report on the Feasibility of a Long-Term Aspirational Goal, Integrated scenario 1, which represents current expectation of future available technologies, operational efficiencies, and fuel availability.

Figure 6: Projection of CO_2 emissions coverage under CORSIA offsetting scheme



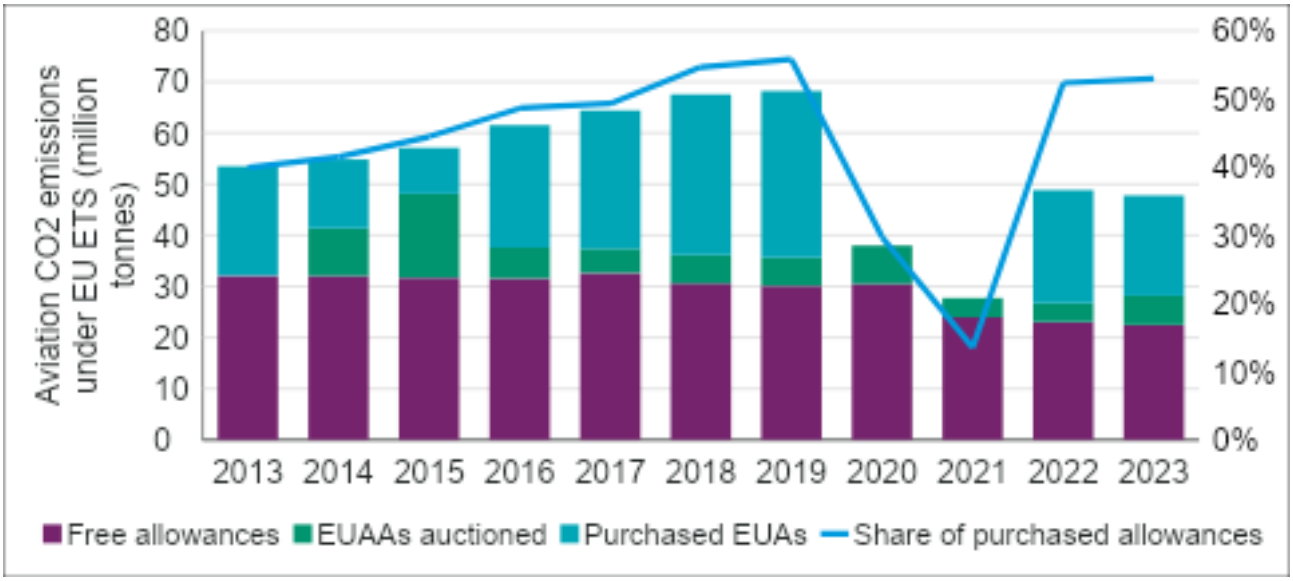
3.2 EU ETS CO_2 EMISSIONS

Emissions from routes under the EU ETS include all CO_2 emissions from intra-EEA flights (and flights to Switzerland and the UK) under MRV requirements (see details in section 1.2.1).

Until the recent revision of the EU ETS Directive (2023/958), only 15% of the emissions allowances allocated to the aviation sector were auctioned. However, since total verified emissions in the sector were higher than total allowances allocated, the sector purchased allowances from other sectors (with lower abatement costs).

Overall, **purchased emissions allowances by operators** include both auctioned allowances allocated to aviation (EUAAs) and EU ETS allowances acquired from other sectors (EUAs). Figure 7 shows the proportion of purchased emissions allowances out of total CO_2 emissions under the scope of EU ETS for aviation. The percentage has been quite stable in the last years at around 40 – 55%, except for 2020-21 period heavily affected by Covid-19 pandemic.

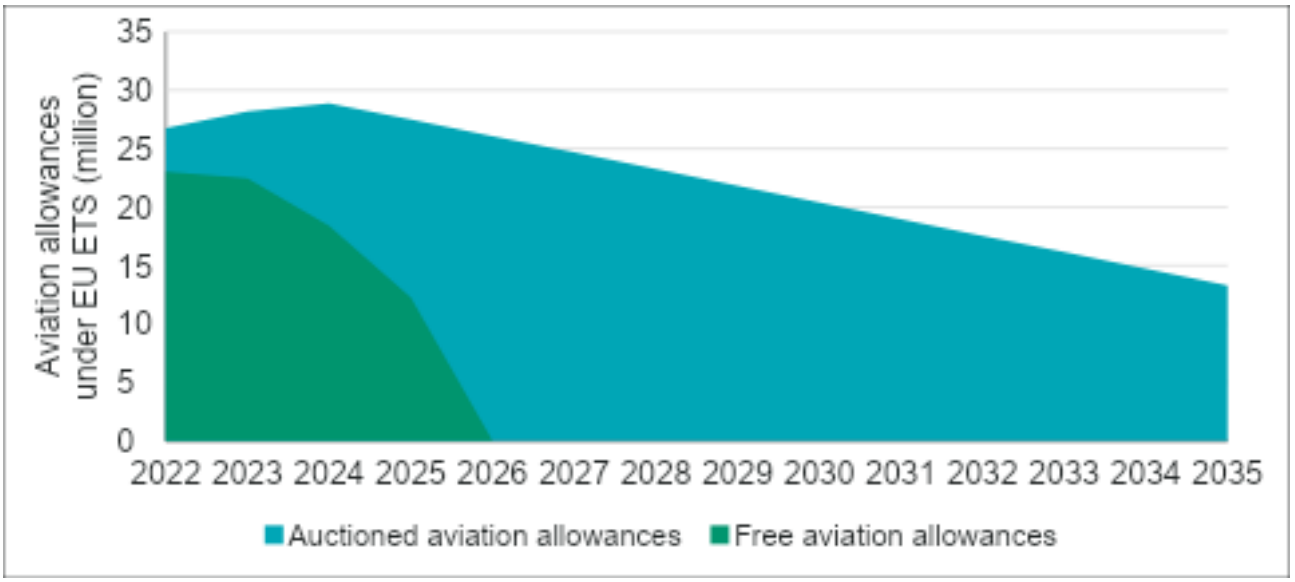
Figure 7: Purchased allowances, both in-sector EU Aviation Allowances (EUAAs) and out-of-sector EU Allowances (EUAs), and free allowances out of total CO_2 emissions within the scope of the EU ETS for aviation from 2013 to 2023



Source: Ricardo analysis based on European Union Transaction Log (EUTL) data published by the European Environmental Agency (EEA)

Free allowances to aeroplane operators will reduce progressively by 25% and 50% in 2024 and 2025 respectively, leading to the ultimate elimination of free allowances after 2026. This means that from 2026 operators will need to purchase EU ETS allowances for 100% of their reported CO_2 emissions. Figure 8 below show the expected projection of aviation allowances under ETS, considering the latest decision on the 2024 cap[39] and linear reduction factors for the next few years.

Figure 8: Projection of aviation allowances under the EU ETS 2022-2035



Source: Ricardo analysis based on European Union Transaction Log (EUTL) data published by the European Environmental Agency (EEA) and Commission Decision (EU) 2023/2440 on the 2024 cap for aviation

3.3 Non-CO_2 emissions

Aviation non-CO_2 emissions that affect climate include nitrogen oxides (NOx), aerosol particles (soot and sulphur-based), and water vapour. Water vapour and aerosols have small direct radiative effects but are also involved in the formation of contrails and contrail cirrus, currently the largest non-CO_2 effect on climate[40].

Evidence suggests that non-CO_2 effects may be significantly greater than those due to CO_2 emissions alone. Research from EASA estimated that non-CO_2 are responsible for about two thirds of the climate impact of aviation[41]. While the effect of non-CO_2 emissions has been estimated at an aggregate level, the measurement of their climate impact (e.g. via a calculation of the CO_2 equivalents) at an airline or individual flight level is quite complex, as it is strongly dependent on the emission location (in particular cruise altitude) and emission time (e.g. weather conditions) and, thus, with a highly non-linear relationship to the fuel consumption[42].

There are important trade-offs in the abatement of CO_2 and non-CO_2 emissions. For example, increasing flight altitude leads to reduced fuel consumption due to reduced aerodynamic drag, but increases the climate impact of non-CO_2 emissions (O_3[43], H_2O and probably contrails and contrail induced cloudiness). This means

[39] Commission Decision (EU) 2023/2440, available at: Decision - EU - 2023/2440 - EN - EUR-Lex (europa.eu)

[40] Uncertainties in mitigating aviation non-CO_2 emissions for climate and air quality using hydrocarbon fuels (rsc.org)

[41] The Effective Radiative Forcing (ERF) from the sum of non-CO_2 impacts yields a net positive (warming) that accounts for more than half (66%) of the aviation net forcing in 2018, but the uncertainty is about 8 times more than CO_2 to the overall uncertainty, as per the EASA study "Updated analysis of the non-CO2 climate impacts of aviation and potential policy measures pursuant to EU Emissions Trading System Directive Article 30(4)", available at: resource.html (europa.eu)

[42] Integration of Non-CO2 Effects of Aviation in EU-ETS and under CORSIA (umweltbundesamt.de)

[43] Altitude emissions of NOx are implicated in the production of ozone (O_3) and the destruction of methane (CH_4), both greenhouse gases. Current scientific understanding is that this leads to an overall net increase in global warming.

that market-based measures (and other policy instruments) should ideally cover both CO_2 and non-CO_2 emissions to incentivise an effective climate mitigation considering these trade-offs.

There are plans at EU level to monitor non-CO_2 emissions from aviation and eventually include them in the EU ETS scope. Directive 2023/958 requires the inclusion of non-CO_2 emissions in the MRV reporting scope, starting from reporting year 2025. The report should at least contain the three-dimensional aircraft trajectory data available, ambient humidity, and temperature for the Commission to estimate the non-CO_2 impacts as equivalent CO_2 emissions per flight. By the end of 2027, based on the results of the MRV of non-CO_2 aviation effects, the European Commission will submit a report and, if appropriate, a legislative proposal after having carried out an impact assessment on expanding the scope of the EU ETS to include non-CO_2 aviation effects. To complement this, EASA has kicked off a network of experts on non-CO_2 effects, ANCEN[44], with the aim of enabling "a coordinated approach across a wide range of stakeholders (e.g. research, industry, regulators, and policymakers), to provide objective, timely, consensual, and credible technical advice".

In contrast, there are no plans to monitor or include non-CO_2 effects under CORSIA. ICAO is organising a Symposium on non-CO_2 emissions in September 2024, which will explore future activities and measures to potentially mitigate and address these effects, considering the existing scientific uncertainties.

4. CARBON PRICE UNDER CORSIA AND EU ETS

This section analyses the carbon price perceived by operators under CORSIA and EU ETS, respectively. The price signal is essential to properly internalise climate costs generated by aviation activities and to contribute to close the price gap between conventional and low/zero-carbon fuels and technologies. Since carbon prices are likely to be passed on to final users, effective carbon prices on operators will also contribute to managing demand in line with climate mitigation targets. The analysis shows that prices for EU ETS allowances are significantly higher than those of CORSIA carbon offsets.

4.1 CORSIA

There is currently a high uncertainty around the price of carbon offsets eligible under CORSIA due to the nascent stage of the market for CORSIA eligible units and the lack of open access platforms with robust data on price of carbon offsets for this market.

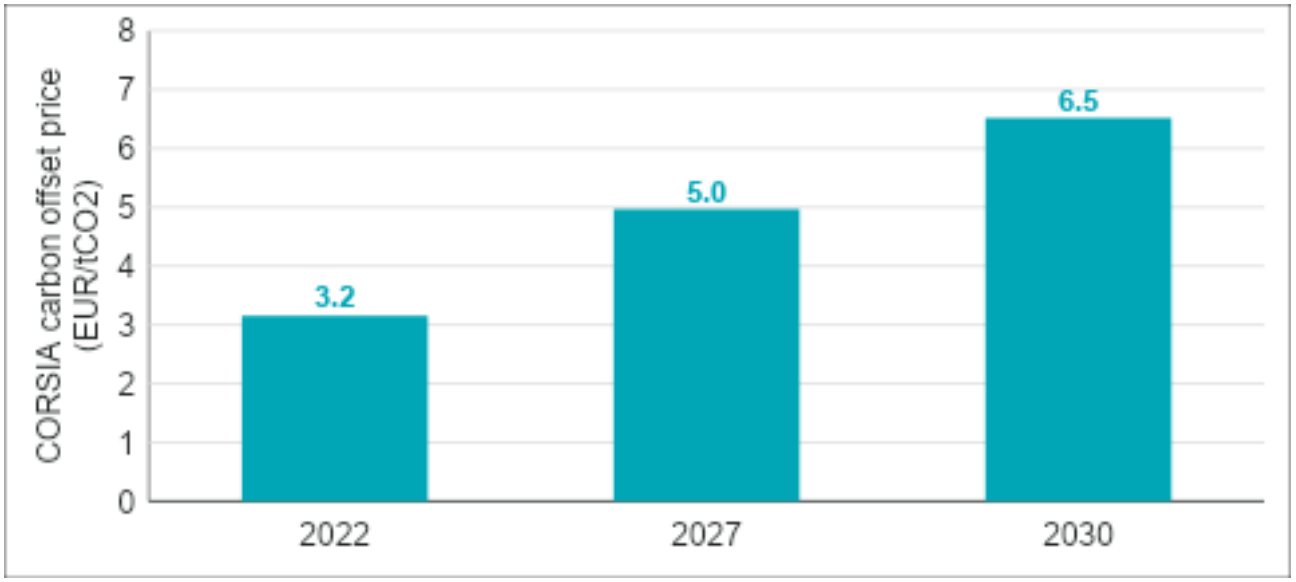
A recent report from ICAO[45] conducted a scenario-based analysis of CORSIA eligible emissions units from 2021 to 2026 using available historical data of voluntarily transacted offsets to provide indicative low, medium, and high price estimates. These have been presented in Figure 9 below. However, data reported on the futures market of CORSIA Eligible Emissions Units (2024-2026)[46] suggests that prices could be significantly higher than those expected by ICAO, at around 7-15 EUR/tCO_2 by 2026.

[44] https://www.easa.europa.eu/en/newsroom-and-events/press-releases/easa-kicks-experts-network-tackle-effects-non-co2-emissions

[45] CAEP/12, Analyses in Support of the 2022 CORSIA Periodic Review: Focus on costs to States and operators, available at: Microsoft PowerPoint - 2_CAEP_CORSIA Periodic Review (C225)_Focus on Costs.pptx (icao.int)

[46] CORSIA Eligible Emissions Units (2024-2026) Futures Pricing (ice.com)

Figure 9: Projected price of CORSIA carbon offsets in the period 2022-2030



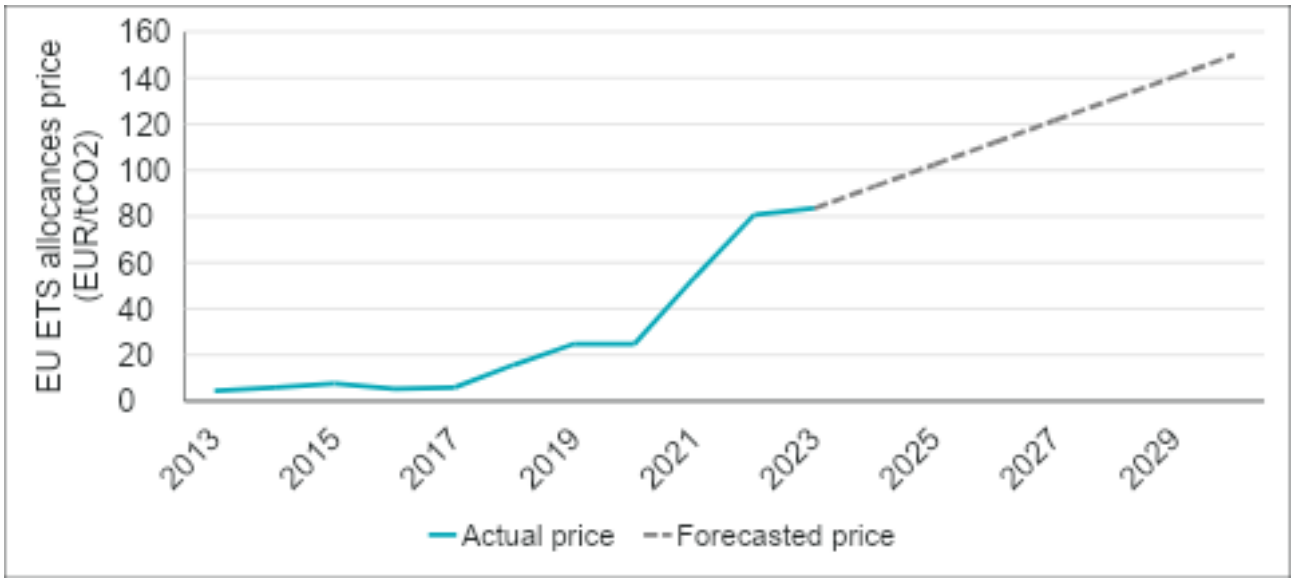
Source: Ricardo analysis

Note: CORSIA carbon offset prices are based on the mid scenario of the CAEP/12, Analyses in Support of the 2022 CORSIA Periodic Review. Expected growth rate of 9.5% has been extended from 2026 to 2030. Prices have been converted from USD to EUR using a 0.935 EUR/USD exchange rate

4.2 EU ETS

The price of EU ETS allowances has increased significantly in the last years and reached a value around 80 EUR/tCO_2 in 2030. Recent projections[47] indicate that the price of allowances in 2030 could be around 150 EUR/tCO_2 (see Figure 10).

Figure 10: Price of EU ETS allowances in the period 2013 – 2023 and projected price by 2030



Source: Ricardo analysis

Note: Actual price data extracted from International Carbon Action Partnership and 2030 projection estimated at 150 EUR/tCO_2 were extracted from Bloomberg NEF EU ETS Market Outlook 1H 2024

[47] Bloomberg NEF EU ETS Market Outlook 1H 2024. Available at: EU ETS Market Outlook 1H 2024: Prices Valley Before Rally | BloombergNEF (bnef.com)

5. Illustrative cases of EU ETS and CORSIA application

To illustrate results from sections 3 and 4 above on the emissions coverage and carbon price for EU ETS and CORSIA, we have estimated these indicators for a selection of four illustrative flights (see Table 8). These cover passenger and cargo flights, subject both to EU ETS and CORSIA. These illustrative cases demonstrate significant differences in the level of ambition between EU ETS and CORSIA schemes.

Table 8: Illustration of EU ETS and CORSIA application to a selection of four flights in 2022 and 2030

Illustrative flight	% Priced emissions in 2022 and 2030 (*)	Add-on price in 2022 and 2030 (EUR per pax or tonne of cargo) (**)
Passenger flight Brussels – Athens under EU ETS	2022: 45% 2030: 100%	2022: 5.1 EUR/pax 2030: 21.2 EUR/pax
Passenger flight Brussels – New York City under CORSIA	2022: 0% 2030: 20%	2022: 0 EUR/pax 2030: 0.4 EUR/pax
Freight flight Brussels – Zagreb under EU ETS	2022: 45% 2030: 100%	2022: 102 EUR/tonne 2030: 422 EUR/tonne
Freight flight Brussels – Moscow under CORSIA (from 2027) (***)	2022: 0% 2030: 20%	2022: 0 EUR/tonne 2030: 4.2 EUR/tonne

Source: Ricardo analysis

Note 1: CO_2 emissions per passenger or tonne for each origin/destination were extracted from the ICAO Emissions Calculator

Note 2: (*) Emissions to be offset or allowances to be purchased out of total MRV emissions

Note 3: (**) Assuming full cost pass-through to final users

Note 4: (***) Assuming that Russia effectively implements the CORSIA offsetting scheme from 2027

6. OPtions for the EU ETS revision

The most recent revision of the EU ETS Directive[48] tasks the Commission to make an assessment by 1 July 2026 of the environmental integrity of CORSIA, including how this affects general ambition in relation to the Paris Agreement, the level of participation in offsetting under CORSIA, its enforceability, transparency, penalties for non-compliance, the processes for public input, the quality of offset credits, monitoring, reporting and verification of emissions, registries, accountability as well as rules on the sustainability certification and use of eligible fuels. The report will be accompanied by a legislative proposal, where appropriate, to amend the EU ETS.

The revised EU ETS Directive already sets a preferred option to expand the scope of the EU ETS to extra-EEA flights if the above-mentioned study finds insufficient guarantees of the environmental integrity of CORSIA: "*then the Commission should propose, as appropriate, that the EU ETS apply to emissions from departing flights from 2027, and that aircraft operators be able to deduct any costs incurred from CORSIA offsetting on those routes, to avoid double charging. In parallel, if a third country does not apply CORSIA from 2027, the EU ETS should apply to emissions from flights departing to that third country.*"

The previous study on CORSIA's environmental integrity[49] found a risk that the scheme may only provide a limited climate benefit compared to the case in which international aviation emissions remain unregulated, for three main reasons:

[48] DIRECTIVE (EU) 2023/958

[49] European Commission (2020), Assessment of ICAO's global market-based measure (CORSIA) pursuant to Article 28b and for studying cost passthrough pursuant to Article 3d of the EU ETS Directive. Available at: Assessment of ICAO's global market-based measure (CORSIA) pursuant to Article 28b and for studying cost pass-through pursuant to Article 3d of the EU ETS Directive - Publications Office of the EU (europa.eu)

- Participation in CORSIA might be partial surely by 2027 and still uncertain following the adoption of the mandatory phase.
- CORSIA is unlikely to materially alter the direct climate impact associated with air travel as the price signal that aeroplane operators will face under the scheme is, on its own, not expected to provide sufficient financial incentives.
- The ability of ICAO to enforce compliance with the scheme is limited. Hence, it cannot be guaranteed that all carbon credits used to offset the actual growth in international aviation emissions accurately reflect real and permanent emission reductions that would not otherwise have occurred.

We expect that the upcoming study on CORSIA's environmental integrity might reach similar conclusions, which would mean that the application of CORSIA to extra-EU flights may not be in line with climate targets for aviation in the EU[50].

However, the potential expansion of the scope of the EU ETS to extra-EEA flights in line with the option stated in the Directive is ultimately a political decision involving multiple geopolitical, legal and climate policy aspects.

7. Conclusions

Both the EU ETS and CORSIA offsetting scheme are market-based policy measures aiming at addressing climate impacts from aviation. However, their nature and level of ambition differ substantially. While the EU ETS is likely to provide effective incentives for the aviation sector to decarbonise in line with climate neutrality objectives by 2050 in support of the Paris Agreement's temperature goal, the CORSIA offsetting scheme has been designed to compensate for aviation emissions exceeding a pre-defined baseline with out-of-sector emission reductions. Hence, the CORSIA offsetting scheme (as part of the wider basket of measures adopted by ICAO) is not in line with the long-term global aspirational goal (LTAG) for international aviation of net-zero carbon emissions by 2050 recently adopted by ICAO[51].

With the start of the mandatory phase for CORSIA in 2027, CO_2 emissions subject to CORSIA offsetting requirements are expected to increase substantially, but only if all ICAO Members effectively implement the scheme, including those that have shown reluctancy in the past (e.g. China, Brazil, Russia, India, Vietnam). If all countries participate, emissions from in-scope routes on average across all international flights are expected to be around 84% from 2027. This percentage would be higher when only considering extra-EEA flights, with a coverage higher than 90%.

However, CO_2 emissions to be offset by operators under CORSIA (i.e. in excess of the defined baseline) are still expected to be a small proportion in the next few years, despite the recent update to the baseline to 85% of 2019 emission levels. By 2030, the share of emissions to be offset was estimated at around 20% of total emissions from in-scope routes and 15% of aggregate MRV emissions.

This is in contrast to a much higher proportion of emission subject to carbon price under the EU ETS. In the period 2013 – 2023, operators have covered around 40-55% of their emissions with purchased allowances (both in-sector and out-of-sector). From 2026, no free allowances will be allocated for free, which means that 100% of emissions will be subject to carbon price.

The study also found a great difference in perceived carbon prices between the two schemes. Carbon prices under the EU ETS are expected to be around 10 - 20 times higher than those under CORSIA. Illustrative cases developed for this study also reveal that the ticket add-on price per passenger from EU ETS would be around 50 times higher than that of CORSIA, since this factors in the lower carbon price but also the lower emissions coverage of CORSIA compared to EU ETS.

The low coverage of emissions to be offset under CORSIA along with the very low price of eligible carbon offsets provides very little incentive to mitigate aviation emissions.

[50] To achieve climate neutrality, the European Green Deal sets out the need to reduce transport emissions by 90% by 2050 (compared to 1990-levels). The aviation sector will have to contribute to the reduction.

[51] Long term global aspirational goal (LTAG) for international aviation (icao.int)

The potential expansion of the EU ETS to flights departing from EEA countries (with the option to deduct CORSIA costs) and to flights to/from countries not adopting CORISA from 2027 is the preferred option from the EU if CORSIA is not found to be in line with EU and global climate goals.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