



Working Paper Series

Market-based measures and aviation sustainability in the European Union: an assessment

by

Riccardo Colantuono

09/2021

SEEDS is an interuniversity research centre. It develops research and higher education projects in the fields of ecological and environmental economics, with a special focus on the role of policy and innovation. Main fields of action are environmental policy, economics of innovation, energy economics and policy, economic evaluation by stated preference techniques, waste management and policy, climate change and development.

The SEEDS Working Paper Series are indexed in RePEc and Google Scholar.
Papers can be downloaded free of charge from the following websites:

<http://www.sustainability-seeds.org/>.

Enquiries: info@sustainability-seeds.org

SEEDS Working Paper 09/2021

July 2021

By Riccardo Colantuono

The opinions expressed in this working paper do not necessarily reflect the position of SEEDS as a whole.

Market-based measures and aviation sustainability in the European Union: an assessment

Riccardo Colantuono

University of Siena, Regulation for Sustainability (R4S)

Riccard.colantuono@student.unisi.it

Note for the reader: this paper refers to the existing legislation “Fit for 55” package in the context of the European Green Deal published on the 14th of July 2021, which was being drafted at the moment of writing. The legislation can be accessed here: https://ec.europa.eu/commission/presscorner/detail/en/ip_21_3541.

Abstract

This study analyzes the current status of the civil aviation industry in the context of two market-based measures designed for the mitigation of CO₂ emissions: the European Union Emissions Trading System (EU ETS) and the Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA). These mechanisms are central in the challenge to decarbonize aviation and their principles, structure and coexistence perspectives will be the object of this article.

In the first section of this study the status of the aviation industry in the EU ETS will be described. After a brief explanation regarding the basic functioning of the scheme, a historical perspective will allow to understand how and why aviation has come to a privileged position in the EU ETS, meaning that the system is failing to apply the appropriate price on the sector's emissions which have continued to grow exponentially in the last decade as a consequence of this deficiency. Consequently, some policy suggestions that may correct this issue will be discussed.

The second section analyzes another market-based mitigation mechanism: the Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA). CORSIA is a global scheme adopted in 2016 by the International Civil Aviation Organization (ICAO), which is a United Nations agency. CORSIA has commenced its operations in January 2021 and its historical developments, structure and functioning system will be analyzed thoroughly in this study.

However, scholars and observers have highlighted several issues in its functioning mechanisms that could significantly reduce its effectiveness. These hindrances will be identified and explored in the third section of this study, and may be listed as it follows: voluntary nature and lack of enforcement, issues inherent to offsetting, issues with the rules concerning SAFs, issues with ICAO transparency and industry influence and the decision taken by ICAO to change the baseline year as a response to the COVID-19 pandemic.

The final part of this study is subsequently devoted to comparing CORSIA, the EU ETS and perspectives about their coexistence, as at European level policy options regarding their relationship are currently in the process of being designed. In fact, a proposal for a regulation concerning these issues is currently being discussed in the European Commission and is expected to be adopted in the second quarter of the current year. Once this legislative decision is taken, the challenge of addressing aviation's climate impact from a market-based standpoint may be a step closer.

Introduction

Managing the environmental impact of civil aviation is undeniably one of the most difficult challenges for sustainability advocates. The reasons behind the complexity of this issue are manifold: the complex nature of aviation's climate impact, which combines CO₂ and non-CO₂ warming effects (Lee et al., 2021); the difficulties related to restraining aviation activity due to its importance in connecting nations in a globalized world; technical barriers, industry structure and its lobbying capacity (Efthymiou and Papatheodorou, 2019); the fact that the connection between aviation and climate change has been *de facto* ignored by media and institutions until 2016 (Gössling, 2020); the issue of replacing kerosene with SAFs (Sustainable Alternative Fuels) which is an extremely debated process, as some of these alternative fuels may actually generate worse impacts than traditional fossil fuels (O'Connell et al., 2019, Pavlenko & Searle, 2021). These and other factors have highlighted the necessity to approach the problem of environmental sustainability in the aviation sector from a holistic, multi-dimensional and differentiated standpoint in order to effectively decarbonize one of the most emission intensive transport modality at the moment.

The sector accounts for roughly 2.5% of global CO₂ emissions (which would place it as a top-10 emitter if ranked as a country), but this absolute value is of less concern than its seemingly endless growth. The European Commission predicted in 2018 that international aviation emissions at a global level will be expected to be around 70% higher in 2020 compared to 2005 (Efthymiou and Papatheodorou, 2019). The International Civil Aviation Organization (ICAO) anticipated aviation emissions to increase by up to 300% by 2050 under business as usual (ICAO, 2019a). Climate experts calculated that in the same scenario aviation emissions between 2015 and 2050 will consume 27% of the remaining carbon budget if we assume an attempt to keep the global temperature increase below 1.5°C (Pidcock & Yeo, 2016). This growth has been virtually non-stop since the emergence of the aviation sector, with the exception of the COVID-19 pandemic that has basically halved scheduled flights and revenue passenger kilometers (RPK)¹ (ICAO, 2020a). However, the industry is expecting a rebound with a return to pre-pandemic levels as soon as 2024 (IATA, 2020) and it is clear that if this actually happens the sector will be in a clear conflict with global decarbonization goals (Gössling & Humpe, 2020).

In order to avoid this conflict, a growing number of initiatives are being adopted by national states, supranational organizations and the industry: for example, the European Union is in the process of passing its ReFuelEU Aviation regulation, with the aim of promoting the uptake of SAFs (European Commission, 2020a) while some industrial players have recently published its strategy to reach net zero emissions in 2050, "Destination 2050". In this complex endeavor, a critical role will be played by market-based measures such as the European Union Emission Trading System (EU ETS) and the Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA). These two radically different but interrelated economic mechanisms will be the focus of this study, as reforms are needed and expected in both in order to make these schemes actually meaningful in reducing emissions from the aviation sector.

¹ RPK is defined as "the number of revenue passengers carried multiplied by the distance flown" (British Airways, 2008)

The EU ETS and aviation

The European Union Emission Trading System (EU ETS) is arguably the most renowned transboundary cap and trade scheme of the world, established in 2005 as the first of its kind and designed to fight climate change in a way that is both economically efficient and legally rigorous (Borghesi et al., 2016). As article 1 of the EU ETS directive² states, the EU ETS is a trading scheme of the European Union's greenhouse gasses (GHG) emission allowances designed to cover around 45% of total emissions in the participating countries. The system entitles the EU Commission to set a yearly EU-wide cap of European Union Allowances (EUAs) that correspond to equivalents of CO₂ metric tons. Allowances are allocated within the EU and the installations subject to the scheme's application have to monitor and report their GHG annual emissions in order to surrender every year a quantity of allowances equal to their emissions produced in the previous year. These installations may comply with this obligation by improving their environmental performance (i.e. cutting their GHG emissions) or by buying the EUAs on the related auctioning and trading market.

These allowances are mainly allocated through an auctioning mechanism, even if many sectors receive some permits for free through the so called grandfathering method (aviation, as we will see, is one of them) in order to avoid delocalization of their activities toward countries not covered by the system. The main rationale here is that the scarcity of the available EUAs should create an incentive for the operators to invest in low-carbon technologies while giving them the possibility to sell their surplus allowances or to buy them if needed to match their reported emissions. The auctioning system, which was one of the main novelties introduced by EC directive 2009/29 to reform the allocation process of EUAs in the scheme, is regarded as the simplest and most economically efficient method of allocation that is capable at the same time of ensuring carbon market stability, reinforcing the carbon price signal and mitigating CO₂ emissions in a cost-efficient manner. It is interesting to point out that the EU ETS Directive maintains that Member States shall determine the use of revenues generated from the auctioning of allowances abiding by a series of rules designed to make mandatory devoting at least 50% of the revenues generated from the auctioning of allowances to initiatives oriented toward climate change mitigation, ranging from adaption measures to renewable energy development, energy efficiency, and carbon capture and storage, among others.

Aviation was effectively incorporated in the EU ETS since the 1st of January 2012, and required all airlines departing or arriving at an EU airport to surrender allowances covering the emissions of all EU flights they had operated in a given year. Until at least 2020, all flights from or to European airports were envisaged to be included in the scheme, apart from a few exemptions. However, following an international outcry³ and in order to ease ongoing negotiations at the International Civil Aviation Organization (ICAO) where carriers were negotiating a global mitigation mechanism, the European Union decided to limit the coverage of the EU ETS to emissions from internal flights within the European Economic Area (EEA) (i.e. flights departing and arriving at an airport in the EEA) for the period from 2013 to 2016 (the so-called "stop-the-clock" decision). When minimal progress was made at ICAO's 38th assembly in October 2013, the clock was

² From now on, when referring to the EU ETS Directive, I will refer to the EC Directive 2003/87 as amended by EC Directive 2009/29 even when not citing both.

³ The USA, China and some other countries claimed that the unilateral implementation of EU ETS to non-European carriers violated the 1944 Chicago Convention. After a negative response from Europe's representatives, Airlines for America (A4A) appealed to the European Court of Justice which ruled that the application of the EU ETS to aircraft operators does not infringe any international agreement. Still, to avoid growing international reaction against the scheme, the "stop-the-clock" decision was taken (Efthymiou and Papatheodorou, 2019).

stopped again. In 2016, ICAO finally managed to agree on a global measure, CORSIA (the Carbon Offsetting and Reduction Scheme for International Aviation, which will be the subject of the next section) and the Commission proposed to extend the exemption indefinitely, pending a review of the effectiveness of the scheme. The co-legislative process eventually settled on an extension until 2024, when further details about CORSIA and its alleged efficacy will be known. In addition, other types of flights are excluded from the scheme: military, circular and Public Service Obligation flights; flights with airplanes with maximum certified take-off weight of less than 5700 kg; flights by airlines with fewer than 243 flights for three consecutive four-month periods or those with annual emissions under 10.000 Mt per year.

It is safe to assume at this point that much of the functioning of the scheme as a whole depends on the quantity of allowances issued every year. This is set at the EU level by a decision (which is a mandatory legislative EU act) adopted by the European Commission, meaning that there is an EU-wide cap set at a central level. For the aviation sector, from 2013 until 2020, the total quantity of allowances allocated to aircraft operators is limited to 95 per cent of the average historical aviation emissions of the years 2004–2006 (so-called overall “cap”). Aircraft operators have the option to use up to 15% of the auctioned allowances from the greater pool of EUAs; from those traded by other aircraft operators (European Union Aviation Allowances, EUAAs); and from other eligible international projects (limited to a maximum of 1.5% of the annual verified emissions). Regarding the allocation method, the Directive states that 82% of allowances are allocated for free to aircraft operators while 15% is allocated through the auctioning system (the remaining 3% go to a special reserve for later distribution to new entrants and fast-growing airlines). The actual allocation of allowances is scaled down from 2013 to 2023, to take account of the temporary reduction of the scope of the EU ETS to flights between airports in the European Economic Area (“stop-the-clock”). Nevertheless, sustainable transportation experts have calculated that the airline sector received an estimated 32.3 million tons of free allowances in 2019, a subsidy estimated at €810 million (Transport & Environment, 2020).

This significant percentage of free allowances given to the sector is one of the reasons why aviation emissions since 2013 have increased 27.6% compared to a 19.7% decrease for other sectors in the ETS (Transport & Environment, 2020). Moreover, between 1990 and 2018 total EU aviation emissions grew from 1.5% of EU emissions to 3.6%. However, in 2019 aviation emissions on routes covered by the scheme grew only 1.5% (still, compared to an 8.9% decline in other sectors), the smallest increase since the scheme was introduced fully in 2013 (*ibidem*). Researchers have found different reasons behind this declining trend, mainly a fall in demand driven by the “flight shame” narrative, bankruptcies of some airlines but most of all the rising price of EU ETS allowances that grew from around 5€ for allowance in 2017 to around 25€ per allowance in 2019. Price of allowances is determined at primary auctions based on relative demand and supply. The rising trend is the result of several policy measures introduced to stabilize allowance prices and create greater market tightness, such as delaying auctions (the so-called “back-loading”), and introducing mechanisms designed to avoid a surplus of allowances and improve the system’s resilience to shocks (market stability reserve). When the price of allowances is high, operators have an economic incentive to reduce their environmental footprint through operational and technological improvements in order to sell their unused allowances to other polluters. As of June 2021, the price of an EU ETS allowance has risen to around 50€. Nevertheless, in order to bring the sector in line with the goals of the Paris Agreement much more action by regulators is required, inside and outside of the EU ETS.

A policy decision that could be implemented fairly easily is a simplification of the monitoring, reporting and verification (MRV) processes. These practices are the backbone of the scheme but in some cases they are falling short of technological advancements, like the management of SAFs. It is broadly recognized by experts and scholars that MRV is an area where intervening could be simpler than other, more politicized, areas and should be the subject of deep investigation by both government's institutions and scholars. Another sphere where it would be possible to act in order to enhance transparency and effectiveness is the auctions' revenue. Previously in this section it was stated that member states are required to use at least 50% of auction revenues to fight climate change. However, "since the MS do not have any obligation to publish relevant information, it is often unknown how much revenue is generated" (Efthymiou and Papatheodorou, 2019). Mandatory publishing and monitoring collected revenues would certainly contribute to the scheme's concrete environmental benefits. Another issue that was brought up by scholars is the variability between member states regarding penalties for excess emissions as well as administrative fees. A standardization of these processes will improve both the fairness and the efficiency of the whole scheme. Other potential reforms of the aviation ETS that are being considered by the literature and the Commission may involve reducing the cap, discounting the allowances, implementing a minimum price for CO₂ (price floor) and, most importantly, reducing the free allocation of allowances (Graichen and Graichen, 2020).

As a matter of fact, the imbalance between demand and supply in the allowances market remains the most significant issue for the efficacy of the scheme. Even if, as we have seen in the previous paragraphs, some decisions have been taken in order to fix this hindrance, oversupply of allowances can still be considered a structural problem for the EU ETS, at least for the aviation sector. In order to overcome this problem scholars have proposed the idea of a Supply Adjustment Mechanism (SAM) that would allow the supply of allowances to respond to demand (Efthymiou and Papatheodorou, 2019). Moreover, in February, during a Council of the 26 European Union meeting, the Polish representatives brought on a proposal for full auctioning of allowances in the aviation sector stating that "we consider it useful [...] the possibility of preparing appropriate legislative solutions to withdraw free emission allowances for the aviation sector, following a detailed assessment of the impact of the proposed solutions on the aviation sector, including on air traffic forecasts in individual countries" (Council of the European Union, 2020) and they found support in the ministers of Denmark, the Netherlands, Sweden, Finland, France, Italy, Belgium, Hungary, Lithuania plus the European Commission (Bannon, 2020). Consequently, "the commission is considering either gradually increasing the share of auctioned allowances — to 20% in 2023 and eventually 55% in 2030 — or phasing out free allocations entirely" (Hatherick, 2020). If this decision is actually implemented, one of the biggest issues for aviation in the ETS would be eliminated. The European Union is currently preparing its revision of the EU ETS in the context of the European Green Deal and the updated rules for aviation will be a key part of this legislative package. In the final section of this study an in-depth analysis of these potential reforms will be carried out.

However, as anticipated in the introduction, another mitigation scheme for aviation, a global one, started being operative in January 2021. In any case, the environmental effectiveness of CORSIA and the relationship between ICAO's scheme and the EU ETS are far from clear and clashes between the European Commission and ICAO have started to manifest themselves. In the following sections of this study CORSIA's functioning and its links with the European Union Emission Trading System will be analyzed in order to provide a full picture of civil aviation's market-based mitigation perspectives and draw some informed conclusions on the whole topic.

CORSIA: basic principles and functioning

The political process for a creation of a global market-based measure with the objective of controlling emissions from international air transport started in 1997 when the Kyoto Protocol explicitly commissioned the International Civil Aviation Organization (ICAO) this task. ICAO is a specialized agency of the United Nations with the objective of governing the principles and techniques of international air navigation and foster the planning and development of international air transport; as of October 2019, it counts 193 member states (ICAO, 2019b). The first milestone for the implementation of a global mitigation scheme for aviation was in 2010, at the 37th ICAO Assembly, where member states decided to set the goal of carbon neutral growth from the year 2020 onwards (“CNG 2020 goal”); meaning that the sector’s net CO₂ emission after 2020 should have remained under the baseline represented by the same year. This objective later became the backbone of the future CORSIA scheme. The following step can be traced back to the 38th ICAO Assembly, in 2013, where this goal was reasserted and followed by the decision of implementing a global market-based scheme for international aviation as soon as possible. Consequently, at the 39th ICAO Assembly in 2016 this measure was formalized in the form of the Carbon Offsetting and Reduction Scheme for International Aviation. ICAO’s own data from 2017 show how this initiative was considered instrumental for member states in order to achieve the CNG 2020 goal as technical innovations by themselves were considered not sufficient (see figure 1 in the Annex).

The most important feature of this project for our analysis is that CORSIA is an *offset* scheme (contrarily to the EU ETS which is a *cap and trade* scheme). In this type of scheme compliance is achieved through carbon credits. A carbon credit is “a tradable certificate or permit representing the right to emit one ton of carbon dioxide or its equivalent (CO₂e). Carbon credits can be derived by GHG reduction projects that deliver measurable reductions in emissions” (Scheelhaase et al., 2018). Resolution A39-3 adopted in 2016 at the ICAO Assembly outlines the main characteristics of the scheme, which can be summarized in the following way:

1. CORSIA is an offset scheme. Emissions are to be offset at carrier level by purchasing carbon credits or by investing in projects aimed at reducing CO₂ emissions in other sectors.
2. Aircraft operators offsetting requirements can also be reduced through the use of sustainable alternative fuels.
3. Flights between non-participating states or between a participating and a non-participating state are excluded from the scheme, as “all international flights on the routes between States, both of which are included in the CORSIA [...] are covered by the offsetting requirements of the CORSIA” (ICAO, 2016). These routes will be successively referred as CORSIA-routes, and emissions produced on these routes as CORSIA-emissions.
4. CORSIA will consist of three phases: a pilot phase (2021-2023), phase 1 (2024-2026) and phase 2 (2027-2035).
5. In the pilot phase and in phase 1 participation is voluntary. As of July 2020, 88 states have signed up for phase 1 (ICAO, 2020b).
6. In phase 2, CORSIA will become mandatory for “all States that have an individual share of international aviation activities in RTKs in year 2018 above 0.5 per cent of total RTKs or whose cumulative share in the list of States from the highest to the lowest amount of RTKs reaches 90 per cent of total RTKs, except Least Developed Countries

(LDCs), Small Island Developing States (SIDS) and Landlocked Developing Countries (LLDCs) unless they volunteer to participate in this phase”⁴ (ICAO, 2016).

7. In order to minimize market distortions, “the CORSIA does not apply to low levels of international aviation activity with a view to avoiding administrative burden: aircraft operators emitting less than 10,000 metric tons of CO₂ emissions from international aviation per year; aircraft with less than 5,700 kg of Maximum Take Off Mass (MTOM); or humanitarian, medical and firefighting operations” (ICAO, 2016) plus “new entrants” for a period of up to three years each or as long as they do not represent more than 0,1% of total emissions in 2020.
8. The method of calculating the amount of emissions to be offset for each airline changes from the pilot and the first phase to the second phase. Two factors are put into the equation: the carrier’s individual emissions on CORSIA routes and the growth of the aviation sector. In the second phase, more weight is put on the carrier’s individual growth. In this regard an excellent clarification is provided by Scheelhaase et al. (2018):

“In the Pilot Phase and Phase 1, carriers serving CORSIA-routes have to offset their individual CORSIA-emissions in the given year multiplied by the sectors growth factor. The latter refers to the growth between the baseline year (mean of 2019 and 2020 emissions) and the given year, i.e. Emissions to be offset by Carrier x in year t = [CORSIA-emissions_{t,x} * Sector growth_{baseline-given year t}]. The aviation sector growth between the given and the baseline year is defined as: [(CORSIA-emission_{Sgiven year t} – CORSIA-emission_{Sbaseline})/(CORSIAemissions_{given year t})]. Within the voluntary Pilot Phase, states are free to replace the given year t by the year 2020 as basis for their carriers' offsetting requirements”⁵.

“Within Phase 2, the growth factor to be applied to a carrier's CORSIA-emissions will – with an increasing percentage – consider each carrier's individual growth, i.e.: Emissions to be offset by Carrier x in year t = [CORSIA-emissions_{t,x} * (s * Sector growth_{baseline-given year t} + i * Individual growth_{x, baseline-given year t})] where s = 100% and i = 0% between 2027 and 2029; s = at most 80% and i = at least 20% between 2030 and 2032, and s = at most 30% and i = at least 70% between 2033 and 2035; with the ICAO Council recommending the percentage of ‘i’, in 2028 to the Assembly”.

The same scholars provide a valuable diagram concerning CORSIA’s timeline and functioning available for consultation in the Annex (figure 2).

Criticism around CORSIA

Now that the basic technical features of the UN’s global mitigation scheme for aviation have been clarified it is possible to analyze the main critics that have been brought on regarding CORSIA’s functioning and objectives. The NGO Transport & Environment released a briefing in September 2019 called “Why ICAO and CORSIA cannot deliver on climate” in which the authors provided a

⁴ RTK is the revenue ton kilometers, defined as “the revenue load in tonnes multiplied by the distance flown” (British Airways, 2008).

⁵ It is important to note that regarding the baseline year, taking into considerations the effects of the COVID-19 on the sector’s emissions, “On 30 June 2020, the Council of the International Civil Aviation Organization (ICAO) voted overwhelmingly to adjust the carbon offsetting baseline period used for measuring growth of CO₂ emissions under the Carbon Offsetting and Reduction Scheme in International Aviation (CORSIA). The adjusted baseline will only take into account the 2019 CO₂ emissions for the aviation sector, and not the 2020 ones” (Millar, Trock, Bory 2020). This decision will be further discussed in the following paragraphs.

rather critical assessment of the scheme; in this section I will examine the main issues highlighted in the paper, in order to have a broader picture of the topic. According to the authors, the weaknesses that could jeopardize CORSIA's long-term environmental efficacy could be summarized in the following way:

1. Voluntary nature and lack of enforcement;
2. Issues inherent to offsetting;
3. Issues related to the rules concerning sustainable alternative fuels;
4. Issues with ICAO transparency and industry influence.

1. The fact that CORSIA will remain a voluntary scheme until 2027 is theoretically faltering on its own; in addition, even if ICAO stated that the 88 countries that signed up for the pilot and the first phase represent approximately 76% of all international aviation activity (Cockrell and Fiorilli, 2020) as the only countries with a significant share of international flights that declined participation (and are thus expected to be included from 2027) are Brazil, Chile, India, Russia, and South Africa (Schep et al., 2016)⁶, this percentage has been recently revised downwards by a study ordered by the European Commission (see the final part of this section). Moreover, the authors stress the importance of the fact that “a state can decline to participate in Corsia (*sic*) [...] in the post-2027 period through what's known as ‘filing a difference’, i.e. filing a reservation. And if a state does agree to participate in either stage of the scheme, ICAO does not have the legal capacity to ensure full compliance with the measure's obligation” (Transport & Environment, 2019).

2. The experts that worked on the briefing in question have a fairly cynical view of the offsetting system in general, as “unlike a tax, which can be structured to increase over time, or emissions trading, where a declining cap can cause increasing allowance scarcity, offsetting offers the possibility to potentially defer, indefinitely, the need for the purchaser to reduce their own emission” (*ibidem*). The rules concerning offsetting dynamics in CORSIA add a new layer to this issue. In fact, offsets are not all the same: different carbon offset markets and quality assurance standards for carbon offsetting exist at a global level. The environmental effectiveness of a scheme like CORSIA ultimately depends on the quality of the offsets eligible for compliance. These have a great variance as regards their actual environmental impacts: for instance, a study commissioned by the EU has found that a large majority of certificates under the umbrella of the UN's own Clean Development Mechanism (CDM), which is the world's largest offsetting scheme that dates back to 1997's Kyoto Protocol, failed to reduce emissions, as according to the authors just 2% of the CDM's credits have a “high likelihood” of delivering emission reductions in the real world and the scheme as a whole has “fundamental flaws in terms of overall environmental integrity” (Cames et al., 2016).

In June 2019, ICAO decided to address this issue with the creation of a Council of Emissions Unit Criteria (EUC) and the establishment of a Technical Advisory Body (TAB) to evaluate the offsets against these criteria (ICAO, 2019c). During the process that led to the decision regarding the eligibility of the offsets, in February 2020, ICAO was addressed a letter by the International Coalition for Sustainable Aviation (ICSA) where the members of

⁶ At the time of the writing, these authors also included in the list Saudi Arabia and the Philippines, both of which have later decided to sign in for the voluntary phases.

the Coalition urged ICAO, among other suggestions, “to limit CORSIA-eligible units to those from projects (i.e. activities) with a start date of 2020 or later, so that only projects implemented as a direct result of ICAO’s decision to establish CORSIA are eligible. We noted that an overwhelming majority of the credits issued by the Kyoto Protocol’s Clean Development Mechanism (CDM) lack environmental credibility” (ICSA, 2020a). In April 2020, ICAO published its list of eligible certificates which includes CDM credits but only those “issued to activities that started their first crediting period from 1 January 2016 and in respect of emissions reductions that occurred through 31 December 2020” (ICAO, 2020c).

The decision to include only projects set up after 2016 was a political compromise, as the position of environmental groups was opposed to the one held by countries like Brazil, China and India which “wanted older projects included on the approved list in order to cash in on the upcoming surge in demand, particularly after CORSIA becomes mandatory for all ICAO members in 2027” (Morgan, 2020) as the website EURACTIV.com reported. The same website reported some reactions to this decision by experts working at environmental NGOs: Gilles Dufresne, an analyst active in the NGO Carbon Market Watch, stated that the agreement “falls short of the level of ambition needed” but added that it is “better than nothing” and a step in the right direction; Andrew Murphy, working for the NGO Transport & Environment, appeared more cynical saying that the decision is “at best a stop-gap measure until parties to the Paris Agreement agree on a replacement to the Clean Development Mechanism” (*ibidem*).

3. In the previous section, one of the main points of the analysis regarding CORSIA’s functioning referred to the decision that airlines can reduce their offsetting requirements through the use of alternative sustainable fuels. The briefing under scrutiny points out how the actual emission reductions achieved using these fuels depends greatly on the type of fuel used, similarly to what was said in the previous paragraph about offset certificates. In fact, ICAO should have developed rules aimed at ensuring that only certain types of alternative fuels – those that deliver actual emission reduction – could be used; according to Transport & Environment, this was not the case, as these rules exist but “suffer from a number of shortcomings” (Transport & Environment, 2019). The authors of the briefing identify four of them.

First of all, the minimum emission reduction requirement is set at a level that is far too low, being 10% compared to kerosene. “Given the uncertainties that exist in these calculations, it’s therefore possible that alternative fuels used will actually result in emission equal to, or in excess of, kerosene” (*ibidem*). And even if calculations would be precise, 10% is clearly a minor emission reduction, which would be in contrast with other standards such as the European Union Renewable Energy Directive⁷ and with the objectives of the Paris Agreement.

The second issue is related to biofuels GHG emissions caused by indirect land use changes (ILUC) meaning that crops cultivated in order to produce biofuels obviously need agricultural land, which is usually obtained by reducing the space of traditional crops such as wheat and maize; nevertheless, food demand still needs to be met and this means that overall more land is needed. ICAO has included some rules to account for this issue, but as the briefing puts it, “the method proposed by ICAO of calculating the emissions is based on overly optimistic assumptions, resulting in underestimated ILUC values” (*ibidem*).

⁷ For instance, the Recast of the Renewable Energy Directive (RED II) which entered into force in the EU in 2018, requires biofuels to achieve GHG savings of at least 65% respect the fossil fuel comparator.

Another hindrance is the absence of wide sustainability criteria regarding alternative fuels, as “a suite of such criteria were developed by technical experts over a number of years, however nearly all of them, including criteria on water rights, biodiversity and food security were rejected by the ICAO council, and only criteria linked to GHG reduction remains. By contrast the EU has already adopted a set of sustainability criteria for alternative fuels through its renewable energy directive (RED), and these are at risk from the significantly weaker Corsia (*sic*) criteria” (*ibidem*).

To conclude the analysis of problems related to alternative fuels rules in the framework of CORSIA it is notable the approval of the crediting of “lower-carbon aviation fuel”. This is a type of kerosene produced in a way that should deliver emission savings relative to the average traditional kerosene production. Nevertheless, it is still a fossil fuel, meaning that it “can hardly be considered ‘alternative’ and its inclusion was done at the behest of Saudi Arabia and with the support of the US” (*ibidem*). In addition, the briefing points out how this decision could cause “cleaner” kerosene to be used under CORSIA while the “dirtier” ones would be used outside of the scheme, “simply becoming an allocation exercise, without reducing overall emissions” (*ibidem*).

4. The last issue analyzed by the briefing is the lack of transparency concerning ICAO’s decision-making processes and the industry influences that affect the organization’s activities. As it was highlighted by the previous points, carbon markets in general and offset schemes in particular are extremely complex, thus they are exposed to risks of non-compliance or not effective compliance if the incumbent operators exploit weak points and ambiguities in order to bypass the scheme’s main objective, i.e. reducing the amount of carbon dioxide emissions of international aviation. A way to avoid this kind of dynamics would be to establish a strong, independent and transparent regulator capable of enforcing CORSIA’s obligations and monitor the actors involved in the scheme. Unfortunately, “ICAO appears neither capable nor willing to act in such a manner. It continues to operate under a high degree of secrecy, declining for example to make public decisions which have been made by its Council or its environment committee (CAEP). NGOs who are observers to the ICAO process, including T&E, are prevented from sharing information without ICAO approval, on threat of expulsion from ICAO. State positions submitted to ICAO are not made public. All this contrasts strongly with the level of transparency which exists in other UN organisations such as its shipping equivalent, the IMO” (*ibidem*). Moreover, the authors of the briefing add that “this level of secrecy also increases the influence of the aviation industry, which enjoys a privileged position at ICAO. When rules are made behind closed doors, with little public scrutiny, that makes it easier for industry to exert its influence”.

In any case, the most significant decision which will contribute to undermine CORSIA’s environmental integrity was not analyzed in this briefing, simply because it occurred after its publication. The aviation sector was clearly one of the most hit in the economic crisis that followed the COVID-19 pandemic which started in February 2020. For example, a report by the Air Transport Bureau of ICAO states that airlines are likely to be offering 55-67% fewer seats in 2020 compared to previous estimates (Cockrell and Fiorilli, 2020). Responding to this unprecedented situation, in June 2020, ICAO announced that the baseline (which, as we have seen in the previous section, should have been calculated as a mean of 2019-2020 emissions) would be calculated solely by reference to 2019 emissions. ICAO stated that “using the 2020 emissions figures would cause an inappropriate economic burden on aeroplane operators and contravene the spirit of the CORSIA framework agreed in 2016” (Millar, Trock, Bory, 2020). In 2022 member states will have to decide

whether to continue with the adjusted baseline beyond 2023 or revert to the previously agreed 2019-2020 baseline.

Millar, Trock and Bory (2020) point out how “a coalition of environmental organizations, including the Environmental Defense Fund, Carbon Market Watch and the World Wildlife Fund, have expressed concerns that the change to the baseline will undermine CORSIA’s framework. According to these organizations, if air traffic fails to recover to 2019 levels until 2024, as anticipated by IATA: the adjusted baseline means that airlines will not be required to purchase any carbon credits until then, vitiating ICAO’s goal of achieving carbon neutral growth from 2020 onwards; and the effect of a lower baseline (i.e. the non-adjusted baseline) and lower aviation emissions would have partially netted out. In other words, the aviation industry’s compliance costs with CORSIA would not have increased as lower emissions mean that aircraft operators would be required to purchase fewer carbon credits.”

The International Coalition for Sustainable Aviation (the same NGO that was quoted before in relation to offset certificates’ standards) released a statement the same day that ICAO took the decision regarding the adjusted baseline. The full statement is the following:

“COVID-19 has inflicted tremendous pain and loss on families and communities the world over and has caused extreme hardship for the aviation sector. Our energy in fighting this crisis must be matched in our fight against climate change. The ICAO Council’s decision to further deflate the ambition of CORSIA is a betrayal to future generations, and a slap in the face to the multilateral work to build the program. There is no good reason for the ICAO Council to make this decision now. It is unnecessary given the program’s flexibility, and it is illegal unless ratified by the Assembly. CORSIA was already far below what is needed to avoid climate catastrophe. Airlines, in pushing for this change, have undermined their own case for international action. Given ICAO’s unwillingness to lead, ICSA urges governments to adopt national measures to support the climate ambition that is needed” (ICSA, 2020b).

An even more recent evaluation of ICAO’s offsetting scheme can be derived by a study ordered by the European Commission in September 2020, accessed through a request and analyzed in a briefing by the NGO Transport & Environment in March 2021 (Transport & Environment, 2021). The briefing basically reinforces the remarks that were previously mentioned in this study (lack of environmental integrity, questions around the offsetting system, lack of transparency and enforcement measures) and concludes by stating that CORSIA would cover approximately 35% of global aviation CO₂ emissions, in contrast with previous figures computed by ICAO.

Options for the coexistence of the EU ETS and CORSIA

In any case, even if its actual environmental contribution in the fight against climate change is disputable, CORSIA is here to stay, and it will have to find its place especially in the context of the European Union, where, as we have seen in the first section of this study, the EU ETS for aviation is up and running. In order to understand what are the policy options available for the coexistence of these two schemes in the EU in the near future, in this section I will provide a brief comparison of the two schemes and an analysis of the EU Commission’s roadmap for the legislative initiative to amend the EU ETS in order to implement CORSIA in a way that is consistent with the European Union climate objectives.

Before proceeding with the analysis, it is useful to clearly describe what are these objectives. In October 2014, the EU adopted the so-called “2030 climate & energy framework” which commits the bloc to achieving an emission reduction target of -40% against 1990 levels. As part of the European Green Deal, the Commission proposed in September 2020 to raise the 2030 greenhouse gas emission reduction target, including emissions and removals, to at least 55% compared to 1990: this target was officially adopted in April 2021. It is undisputable that the CORSIA target (the “CNG 2020 goal”, i.e. stabilizing emissions from international aviation at 2020 levels) is inherently weaker than the EU’s 2030 target, regardless of the methods used to achieve the respective targets. Moreover, the EU 2030 target is to be solely achieved through reductions within the EU, whereas CORSIA is built around international credits. The briefing “Why ICAO and CORSIA cannot deliver on climate” published by the NGO Transport & Environment that was already scrutinized in the previous section concludes its analysis by stating that “due to the weaker target and the use of offsets, implementing Corsia (*sic*) in EU law in a manner which replaces existing legal commitments would weaken Europe’s overall climate ambition. According to independent research commissioned by T&E, over the period 2021-2030, Europe’s aviation emissions would increase 683.8 Mtonnes CO₂, which is equivalent to the 2017 CO₂ emissions of Poland and France combined” (Transport & Environment, 2019)⁸.

In order to address these issues, in July 2020 the European Union has published an inception impact assessment (IIA)⁹ regarding a proposal for a regulation called “Revision of the EU Emission Trading System Directive 2003/87/EC concerning aviation”. The legislative initiative is planned for adoption by the EU Commission by the second quarter of 2021. As we have seen in the previous sections of this study, the EU limited the scope of the EU ETS to intra-EU/EFTA flights back in 2017. In case no amendment to the EU ETS Directive will be implemented, the EU ETS is scheduled to revert back to including all flights in, out and within the EU/EFTA from 1 January 2024. In light of this deadline, in the IIA the following policy options are described as to be assessed:

1. “EU ETS full legal scope: In case no amendment is adopted by the European Parliament and Council by December 2023, the EU ETS for aviation would cover flights departing from airports in the EU/EFTA and arriving to other airports in EU/EFTA or to third countries and, if not exempted through delegated legislation, incoming flights to airports in the EU/EFTA from third countries (exercising empowerment in Article 25a of the EU ETS Directive).
2. Intra-EU/EFTA ETS only: Maintaining the status quo, the EU ETS would be applied exclusively and confined to the scope of the system as currently applied: allowance surrendering obligations for aircraft operators would be based solely on emissions from flights between aerodromes located in the EU/EFTA, with the exception of flights between EU outermost regions and other regions of the EU/EFTA (including other outermost regions), while including flights within any given outermost region. NB: in this option, CORSIA is neither applied to ETS-exempted routes.

⁸ It is notable to remind that these figures were obtained *before* the baseline year change described in the previous section. Given this modification, the increase in emissions would be undoubtably larger.

⁹ “Inception Impact Assessments aim to inform citizens and stakeholders about the Commission's plans in order to allow them to provide feedback on the intended initiative and to participate effectively in future consultation activities. Citizens and stakeholders are in particular invited to provide views on the Commission's understanding of the problem and possible solutions and to make available any relevant information that they may have, including on possible impacts of the different options” (European Commission, 2020b).

3. CORSIA only: Only CORSIA would be applied to international flights, non-domestic intra-EU/EFTA flights, flights to and from the EU/EFTA States (including their outermost regions) and third countries.
4. ETS-CORSIA “clean cut”: The EU ETS would continue to apply to the current intra-EU/EFTA scope, as in option 2 above, and CORSIA would be introduced for extra-EU/EFTA flights, i.e. flights to and from EU/EFTA States (including their outermost regions) and third countries. In other words, the EU ETS would be applied as at present and CORSIA would be applied to all other flights (to the extent that CORSIA is applicable to them).
5. ETS-CORSIA “mix”: Regarding non-domestic intra-EU/EFTA flights, the EU ETS would apply up to each operator’s 2020 emissions. Above the 2020 emissions, CORSIA would apply. Regarding flights between EU/EFTA States (including their outermost regions) and third countries, CORSIA would apply on emissions above 2020 levels. This option would cover domestic flights.
6. ETS-CORSIA “mix” according to licence of aircraft operators: The EU ETS would apply to non-domestic, intra-EU/EFTA flights, operated by operators with licences issued by Member States. For operators with licences issued by third countries, only CORSIA would apply on those non-domestic intra-EU/EFTA flights and flights between EU/EFTA States (including their outermost regions) and third countries. This option would not cover domestic flights” (European Commission, 2020b).

In parallel, the commission plans to examine the following policy options regarding the share of the free allocations of allowances for the aviation sector, as anticipated in the final part of the first section:

0. “Status quo: The current legally situation is perpetuated until 2030, i.e. the 15% auctioning share.
1. Immediate phase-out: 100% auctioning from the entry into force of the revision.
2. Swift phase-out: Full auctioning by 2025, starting with an auctioning share of 60% in 2023, and a share of 80% in 2024.
3. Slow phase-out: A linear increase year-by-year to full auctioning by 2030 starting from 20% in 2023.
4. Slow reduction: A linear increase year-by-year starting with an auctioning share of 20% in 2023 and ending at 55% in 2030” (*ibidem*).

These policy options regarding the ETS and CORSIA’s coexistence as well as the auctioning system reforms will be assessed by the Commission in specific sections, namely likely economic impacts, likely social impacts, likely environmental impacts, and likely impacts on simplifications and/or administrative burden. The document concludes by stating that “an impact assessment is being prepared to support the preparation of this initiative and to inform the Commission's decision. This work has started in 2019 and the assessment is planned to be completed by the end of 2020” (*ibidem*). The adoption of the EU ETS reform due by mid-2021 will therefore be an opportunity to amend the currently faulty aviation emission mitigation system in a way that it is consistent with the obligations of the Paris Agreement, at least in the context of the European Union.

However, some research has already been carried out in this direction, making it possible to draw some early insights on the possible choices. In fact, a report published by Van Velzen et al. (2019) which investigates the costs for European airlines for two envisaged options, plus an add-on taking into account the impacts of the COVID-19 pandemic on the sector, makes it possible to understand

more clearly the actual environmental contributions of these policy options. The scenarios investigated by these scholars are:

1. “Retain EU ETS for aviation + CORSIA for outbound. The EU ETS will be retained for all intra and domestic EEA flights, in line with its current application. Also the flights between the EEA and Switzerland will be subject to the EU ETS in line with the current linking agreement. CORSIA will apply to flights between EEA Member States and other participating ICAO Member States (outbound flights), but the intra EEA flights subject to the EU ETS will be exempted from CORSIA” (*ibidem*). This option can be juxtaposed to option 4 in the Commission’s IIA, namely ETS-CORSIA “clean cut”.
2. “Retain EU ETS for aviation + CORSIA for intra and outbound. The EU ETS will be retained for all intra and domestic EEA flights, in line with its current application. Also the flights between the EEA and Switzerland will be subject to the EU ETS in line with the current linking agreement. CORSIA will apply to intra EEA flights and flights between EEA Member States and other participating ICAO Member States (outbound flights)” (*ibidem*). This option has not been analyzed by the Commission yet.

The authors assumed for both scenarios an adjustment of the EU ETS aviation cap on the basis of a linear reduction factor of 2.2% per year and a reduction of freely allocated allowances for aviation of 8.5% per year, implying that by the year 2030 all aviation allowances will be auctioned. In addition, the study assesses different price variations for both ETS and offsets: a higher price scenario which predicts ETS allowances to go up to around €43 (in real terms) in 2024/2025 followed by a price stabilization in the period 2025-2030, with offsets prices rising from 8\$ in 2020 to 15\$ in 2030, and a lower price scenario with ETS allowances trading at €20 (in real terms) for the whole period 2021-2030 with offsets prices reaching 10\$ in 2030. Given the price level of around 50€ per allowance reached at the time of this publication, the higher price scenario seems the proper one.

In the subsequent add-on, figures have been adjusted in order to include the consequences that the COVID-19 pandemic had on the sector. A 50% decrease of aviation emissions in 2020 relative to 2019 has been estimated and the projected emission baseline for the year 2030 has been revised, adopting a “U-shape” recovery scenario which assumes that over the period 2021-2024 international aviation will gradually recover bringing the emissions of the year 2024 back to the level of 2019 (see figure 3 in the Annex). Next, the demand for EU ETS allowances and CORSIA offsets has been re-computed, considering the previously mentioned decision of the ICAO council to adopt the year 2019 as the sole basis for the baseline emissions.

It is interesting to note that “in case of both co-existence scenarios the demand for CORSIA related international credits is heavily affected by COVID-19. Compared to the original study for the full period 2021-2030 demand is reduced by about 50% [...] Because in the first 4 years of CORSIA (2021-2024) CO₂ emissions are below the 2019 baseline emission level, the sectoral growth rate is negative. This implies under the U-shape baseline scenario there will be no offset obligations under CORSIA in this 4-year period. This will be the case for all international routes covered by CORSIA. Interestingly the reduction in offset demand is not so much directly related to the lower levels of emission under the COVID-19 baseline scenario, but much more to the decision of the ICAO council to change the CORSIA baseline from the average of 2019/2020 to 2019. Actually in case the average of 2019/2020 would have remained the CORSIA baseline under the COVID-19 baseline scenario, the offset demand would have gone up relative to the pre-COVID situation” (Van Velzen, 2020).

The conclusions of this study provide a picture that, from an environmental point of view, is far from inspiring. Figure 5 in the Annex reports the additional costs as a percentage of total airline operating costs for every scenario: these percentages can also be regarded as the increase in ticket prices if airlines would pass on all the mitigation costs. In fact, the cost of applying CORSIA to only extra-EU flights would amount to €476 and €706 million for the low and high price scenario respectively, representing only 0,2% of airlines' operating costs. The extra cumulative costs for European airlines of applying CORSIA on intra-EU ETS routes goes from €278 million for the lower price scenario to €412 million for the higher price scenario, representing 0,1% of airlines' operating costs. As figure 4 in the Annex shows, projected costs of the EU ETS are far greater.

The study commissioned by the EC which was mentioned before in relation to CORSIA's environmental effectiveness provides an analysis of the previously mentioned proposal for a regulation as well. In fact, it states that "full scope EU ETS brings highest environmental & economic benefits" (option 1) as this choice is associated with the "largest decrease in intra-EU/EFTA and global net aviation CO₂" (Transport & Environment, 2021). On the contrary, option 3 (CORSIA only) is "associated with the biggest global net aviation CO₂ emissions increase" (*ibidem*). Retaining, expanding and amending the EU ETS for aviation thus becomes vital in order to effectively price aviation emissions, enable a sustainable transition of the industry and push the aviation sector towards cleaner alternative fuels, which are still currently much more expensive than traditional kerosene.

Conclusions

This study provided an analysis of the perspectives for the aviation industry to implement a sustainable transition in the context of market-based mechanisms, in a way that is in line with environmental treaties agreed at global and regional level. In the introduction it was highlighted how this sector has been historically excluded from the sustainability conversation as its economic importance has frequently outweighed considerations about its environmental impacts. However, this situation has changed as in last years aviation's contribution to climate-warming GHG emissions has constantly grown on a year-on-year basis on par with its economic growth. Scenarios about future developments of the industry show only a reinforcement of this trend, and even if the COVID-19 pandemic is having a substantial impact on the sector, several policy actions are needed in order to effectively reduce aviation's environmental impacts and implement a sustainable transition in the flying industry.

The main measures that should be enacted in order to reach this objective, beyond operational and technical improvements, are considered to be market-based measures and sustainable alternative fuels: around this statement is present a broad scientific consensus which is also shared by the aviation industry, as figure 1 in the Annex shows. Given this, the study analyzed the two most important market-based measures that include the civil aviation industry into their actors, namely the European Union Emission Trading System (EU ETS) and the Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA). The functioning of both these schemes was analyzed and an assessment of their recent and future developments was provided.

The initial section was dedicated to the basic functioning mechanisms of the EU ETS, which was defined as a cap and trade scheme based on tradable auctioned allowances that give operators the right to emit a limited yearly quantity of GHG. Then, a special focus on the status of the aviation industry in the EU ETS was provided: as we have seen, the sector maintains a privileged position in

the scheme as the coverage is limited to intra-EEA flights only and 82% of its allocated allowances are currently given out for free. This situation may change as soon as the European Union will implement its reform of the system in the course of the current year.

In the following section the analysis shifted toward CORSIA and the United Nations specialized agency which guided its creation, the International Civil Aviation Organization (ICAO). This scheme was defined as an offset scheme, meaning that compliance is achieved through the purchase of carbon credits that can be derived by GHG reduction projects that deliver measurable reductions in emissions. After describing in detail the functioning of CORSIA, the consequent section was dedicated to a critical analysis of the scheme: observations about its actual environmental impacts which were pointed out by the environmental NGO Transport & Environment were reported and discussed, finding a number of structural faults that may jeopardize the GHG mitigation potential of CORSIA.

Lastly, options for the coexistence of the EU ETS and CORSIA plus an outlook of possible EU ETS reforms regarding aviation were described, analyzing a document published by the EU Commission which should take a final decision in this respect by the second quarter of 2021. Further observation and research will be necessary in this context, as reforms of market-based measures like the reduction of freely allocated allowances in the EU ETS could have both the direct effect of reducing aviation's environmental impact inside the scheme (as incumbent operators would have a greater economic incentive toward emitting less GHG) and the indirect effect of making SAFs more attractive at market level, as the relative cost of reducing emissions through allowances compared to SAFs-driven reduction would rise. In this context, the greatest responsibility rests in the hand of the EU Commission and its future decisions. As of CORSIA, this study showed that if the scheme will not be profoundly ameliorated its environmental effectiveness will remain minimal, especially if the economic effects of the currently ongoing COVID-19 pandemic will continue to shrink its already weak environmental targets.

Bibliography

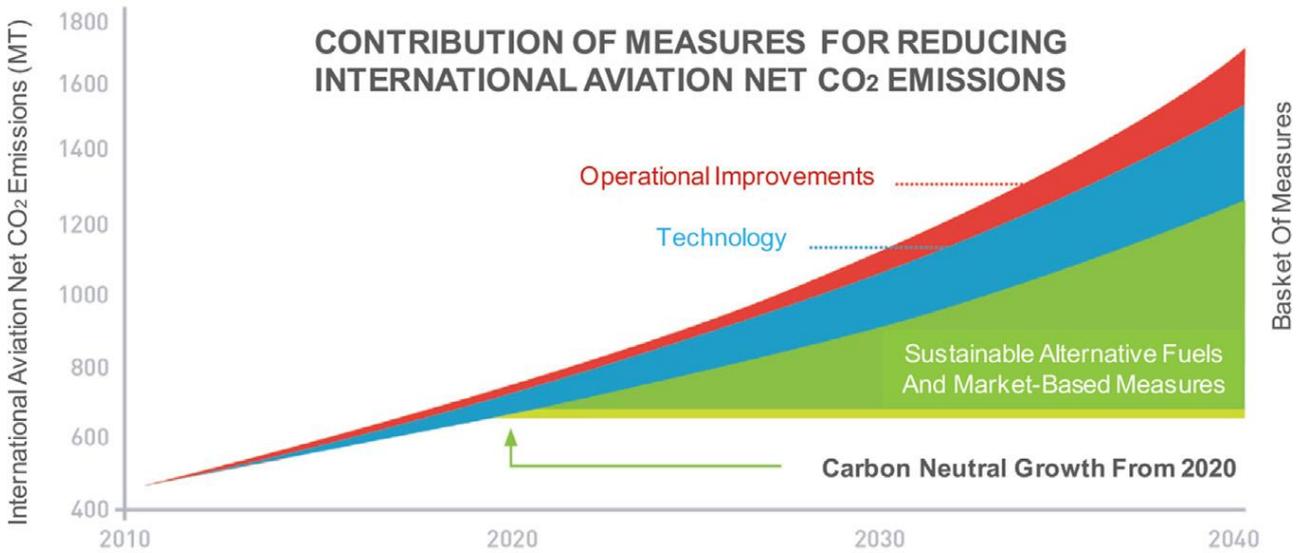
- Bannon, E. (2020, March 05). EU governments voice support for ending airlines' free pollution. Retrieved from <https://www.transportenvironment.org/press/eu-governments-voice-support-endingairlines'-free-pollution-permits>
- Borghesi, S., Montini, M., & Barreca, A. (2016). *The European emission trading system and its followers: Comparative analysis and linking perspectives*. Switzerland: Springer.
- British Airways (2008). Glossary. Retrieved from https://www.britishairways.com/cms/global/microsites/ba_reports0809/pdfs/Glossary.pdf
- Cames, M., Harthan, R. O., Füssler, J., Lazarus, M., Lee, C. M., Erickson, P., & Spalding-Fecher, R. (2016). *How additional is the Clean Development Mechanism?* (Tech. No. : CLIMA.B.3/SERI2013/0026r). Öko-Institut.
- Cockrell, C., & Fiorilli, V. (2020). Sustainable Aviation: How COVID-19 Moved the CORSIA Goalposts. Retrieved from <https://www.hfw.com/downloads/002222-HFW-Sustainable-AviationHow-Covid-19-moved-the-CORSIA-goalposts.pdf>
- Council Of the European Union (2020, February 18). Implementation of Full Auctioning for the Aviation Sector under EU ETS – Information from the Polish Delegation. Retrieved from <https://data.consilium.europa.eu/doc/document/ST-6116-2020-INIT/en/pdf>
- Efthymiou, M., & Papatheodorou, A. (2019). EU Emissions Trading scheme in aviation: Policy analysis and suggestions. *Journal of Cleaner Production*, 237, 117734. doi:10.1016/j.jclepro.2019.117734
- European Commission (2020a). Sustainable aviation fuels – ReFuel EU Aviation. Retrieved from https://ec.europa.eu/info/law/better-regulation/have-your-say/initiatives/12303-Sustainable-aviation-fuels-ReFuelEU-Aviation_en
- European Commission (2020b). Revision of the EU Emission Trading System Directive 2003/87/EC concerning aviation. Retrieved from https://ec.europa.eu/info/law/better-regulation/have-your-say/initiatives/12494-EU-emissions-trading-system-updated-rules-for-aviation_en
- Gössling, S. (2020). Risks, resilience, and pathways to sustainable aviation: A COVID-19 perspective. *Journal of Air Transport Management*, 89, 101933. <https://doi.org/10.1016/j.jairtraman.2020.101933>
- Gössling, S., & Humpe, A. (2020). The global scale, distribution and growth of aviation: Implications for climate change. *Global Environmental Change*, 65, 102194. <https://doi.org/10.1016/j.gloenvcha.2020.102194>
- Graichen, J.; Graichen, V. (2020). Analysis of potential reforms of aviation's inclusion in the EU ETS. Öko-Institut. Transport & Environment (ed.), 2020. Retrieved from https://www.transportenvironment.org/sites/te/files/publications/2020_11_Oko_Institute_analysis_potential_reforms_aviation_inclusion_ETS.pdf
- Hatherick, V. (2020, July 08). EU mulls ETS aviation changes. Retrieved from <https://www.argusmedia.com/en/news/2121349-eu-mulls-ets-aviation-changes>

- IATA (2020). Recovery Delayed as International Travel Remains Locked Down. Retrieved from <https://www.iata.org/en/pressroom/pr/2020-07-28-02/>
- ICAO (2016). Resolution A39-3: Consolidated statement of continuing ICAO policies and practices related to environmental protection – Global Market-based Measure (MBM) scheme. Retrieved from https://www.icao.int/environmental-protection/Documents/Resolution_A39_3.pdf
- ICAO (2019a). Trends in Emissions that affect Climate Change. Retrieved from https://www.icao.int/environmental-protection/Pages/ClimateChange_Trends.aspx
- ICAO (2019b). ICAO Member States. Retrieved from <https://www.icao.int/MemberStates/MemberStates.Multilingual.pdf>
- ICAO (2019c). CORSIA Emissions Unit Eligibility Criteria. Retrieved from https://www.icao.int/environmental-protection/CORSIA/Documents/ICAO_Document_09.pdf
- ICAO (2020a). Economic Impacts of COVID-19 on Civil Aviation. Retrieved from <https://www.icao.int/sustainability/Pages/Economic-Impacts-of-COVID-19.aspx>
- ICAO (2020b). CORSIA States for Chapter 3 State Pairs. Retrieved from https://www.icao.int/environmentalprotection/CORSIA/Documents/CORSIA_States_for_Chapter3_State_Pairs_Jul2020.pdf
- ICAO (2020c). Recommendations by the technical advisory body - CORSIA Eligible Emissions Units. Retrieved from https://www.icao.int/environmentalprotection/CORSIA/Documents/TAB/TAB_2020/ICAO_Doc_CORSIA_Eligible_Emissions_Units_August_2020.pdf
- ICSA (2020a). Letter from the International Coalition for Sustainable Aviation to the Members of the ICAO Council on CORSIA Offset Program Eligibility for the First Round of Emissions Unit Program Applications [Letter written February 12, 2020 to ICAO]. Retrieved from https://carbonmarketwatch.org/wp-content/uploads/2020/02/ICSA-Letter-to-the-ICAOCouncil_CORSIA-Offset-Program-Eligibility_12-Feb-2020.pdf
- ICSA (2020b). Statement from the International Coalition for Sustainable Aviation on the ICAO Council's weakening of the CORSIA baseline. Retrieved from <https://www.icsa-aviation.org/wpcontent/uploads/2020/07/ICSA-Statement-on-Revision-of-CORSIA-Baseline.pdf>
- Lee, D., Fahey, D., Skowron, A., Allen, M., Burkhardt, U., Chen, Q., Doherty, S., Freeman, S., Forster, P., Fuglestedt, J., Gettelman, A., De León, R., Lim, L., Lund, M., Millar, R., Owen, B., Penner, J., Pitari, G., Prather, M., . . . Wilcox, L. (2021). The contribution of global aviation to anthropogenic climate forcing for 2000 to 2018. *Atmospheric Environment*, 244, 117834. <https://doi.org/10.1016/j.atmosenv.2020.117834>
- Millar, I., Trock, J., & Bory, O. (2020). International: New baseline for CORSIA and proposals for integration within the EU ETS and the UK ET. Retrieved from <https://bakerxchange.com/rv/ff006776bd3acfca509d026bea4d9e7523cbfd1f>

- Morgan, S. (2020a). UN aviation body dumps dodgy carbon credits. Retrieved from <https://www.euractiv.com/section/aviation/news/un-aviation-body-dumps-dodgy-carbon-credits/>
- O'Connell, A., Kousoulidou, M., Lonza, L., & Weindorf, W. (2019). Considerations on GHG emissions and energy balances of promising aviation biofuel pathways. *Renewable and Sustainable Energy Reviews*, 101, 504-515. doi:10.1016/j.rser.2018.11.033
- Pavlenko, N., & Searle, S. (2021). Assessing the sustainability implications of alternative aviation fuels. *International Council on Clean Transportation* (working paper).
- Pidcock, R., & Yeo, S. (2016, August 08). Analysis: Aviation could consume a quarter of 1.5C carbon budget by 2050. Retrieved from <https://www.carbonbrief.org/aviation-consume-quarter-carbonbudget>
- Scheelhaase, J., Maertens, S., Grimme, W., & Jung, M. (2018). EU ETS versus CORSIA – A critical assessment of two approaches to limit air transports CO 2 emissions by market-based measures. *Journal of Air Transport Management*, 67, 55-62. doi:10.1016/j.jairtraman.2017.11.007
- Schep, E., Van Velzen, A., & Faber, J. (2016). *A comparison between CORSIA and the EU ETS for Aviation* (Rep. No. 16.7K17.121). CE Delft.
- Transport & Environment. (2019). Why ICAO and Corsia cannot deliver on climate. Retrieved from https://www.transportenvironment.org/sites/te/files/publications/2019_09_Corsia_assesment_fina_l.pdf
- Transport & Environment. (2020). State of the aviation ETS. Retrieved from <https://www.transportenvironment.org/state-aviation-ets>
- Transport & Environment (2021). Corsia: worst option for the climate. Retrieved from https://www.transportenvironment.org/sites/te/files/publications/2021_03_Briefing_Corsia_EU_assesment_2021.pdf
- Van Velzen, A., De Bruyn, S., & Bachaus, A. (2019). *Costs of the EU ETS and CORSIA for European Aviation* (Rep.). TAKS (Transport Analysis and Knowledge Systems).
- Van Velzen, A. (2020). *Add-on to report "Costs of EU ETS and CORSIA for European Aviation" taking into account the impacts of the COVID-19 pandemic on aviation emissions* (Rep.). TAKS (Transport Analysis and Knowledge Systems).

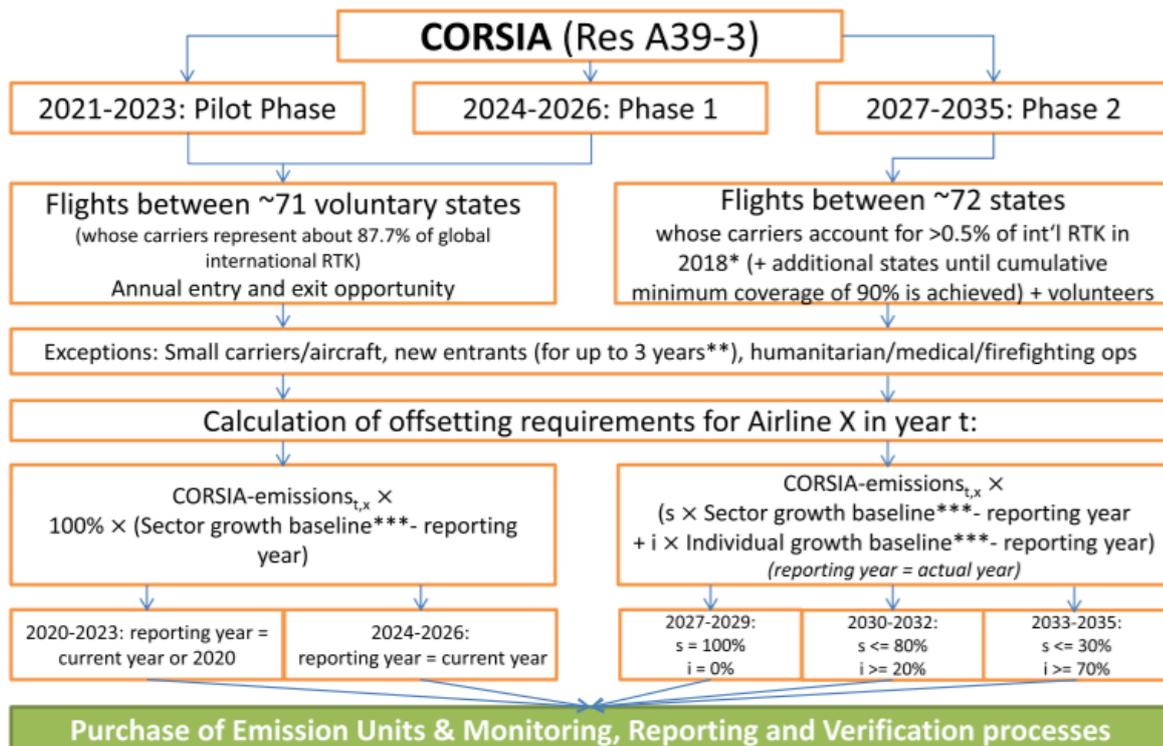
Annex

Figure 1:



Source: CORSIA, via O’Connell et al. (2019).

Figure 2:

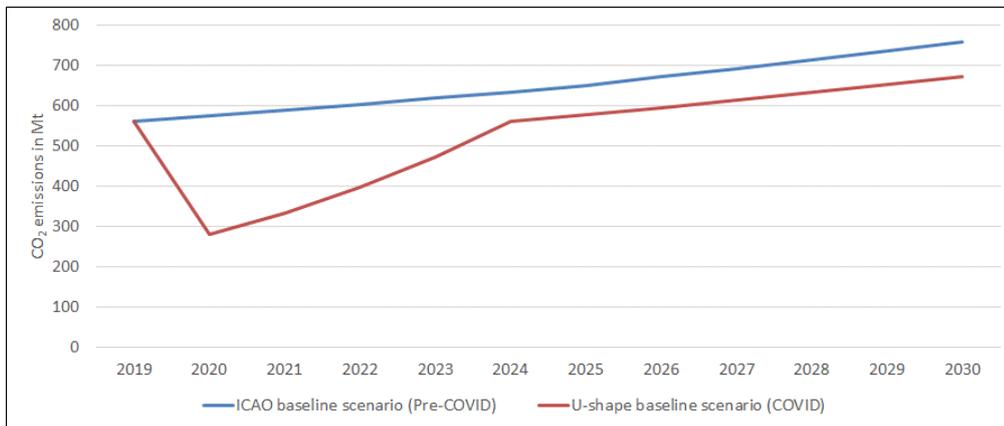


*) Except Least Developed Countries (LDCs), Small Island Developing States (SIDS) and Landlocked Developing Countries (LLDCs) unless they volunteer to participate.

***) as long as a new carrier remains below a 0.1% share of global RTK. *** mean of 2019 and 2020 emissions.

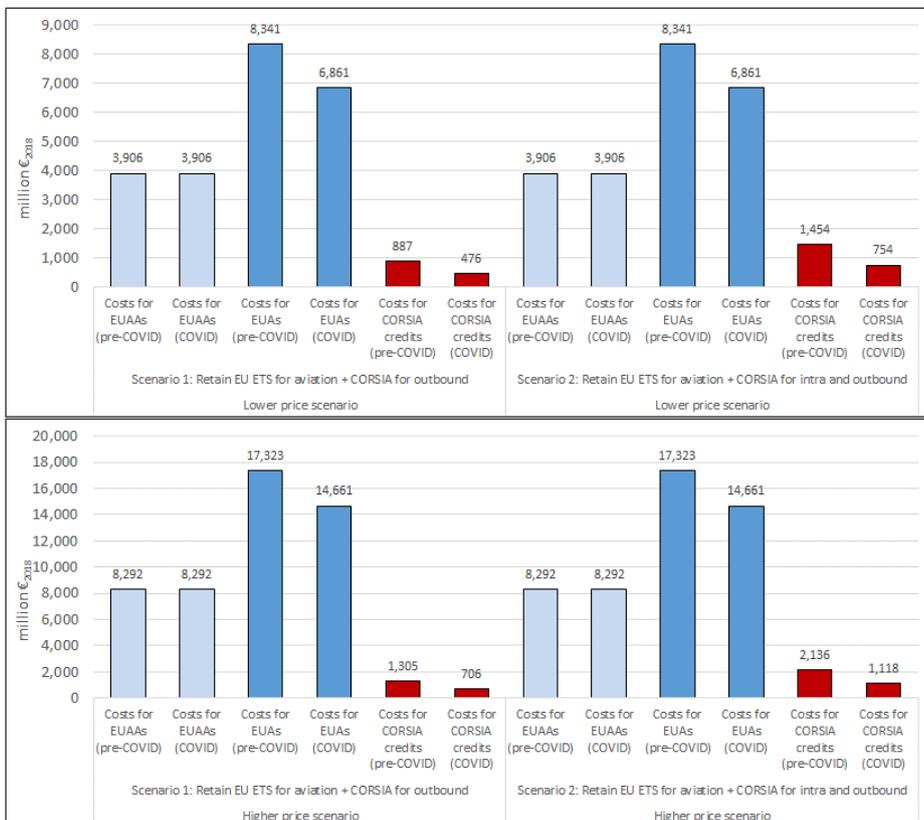
Source: Scheelhaase et al. (2018). Note that some relevant changes have taken place in the scheme after the publication of this graph, such as the number of voluntary states. Refer to the second section for further clarification.

Figure 3:



Source: Van Velzen (2020).

Figure 4:



Source: Van Velzen (2020).

Figure 5:

	Scenario 1. Retain EU ETS for aviation + CORSIA for outbound		Scenario 2. Retain EU ETS for aviation + CORSIA for intra and outbound	
	2021	2030	2021	2030
Lower price scenario				
Intra EEA flights	0.8%	1.7%	0.8%	1.8%
Outbound EEA flights ⁵	0.0%	0.1%	0.0%	0.1%
Higher price scenario				
Intra EEA flights	1.2%	3.4%	1.2%	3.5%
Outbound EEA flights ⁶	0.0%	0.2%	0.0%	0.2%

Source: Van Velzen (2020).