



Assessing the efficacy of EU greenwashing directive: A study of European airlines' voluntary carbon offset programs

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ABSTRACT

This study evaluates the authenticity, verifiability, and alignment of Voluntary Carbon Offset (VCO) claims made by eighteen European airlines, aligning them with proposed EU regulations specifically targeting greenwashing practices. Our analysis focuses on four key components within VCO programs: measurement, integrity, significance, and alignment. Our findings reveal that European airlines are engaging in greenwashing practices in their VCO programs. The most compelling evidence lies in the insignificance and misalignment of these programs, indicating they are implemented without substantial impact on the airlines' mitigation efforts and are not integrated into their strategies. It is essential to clarify that this research does not delve into the intent behind greenwashing practices but rather aims to shed light on the potential for consumer misperception resulting from such practices. Despite some important limitations, the Greenwashing Directive represents a significant step towards enhancing transparency within the environmental sector, aligning closely with established academic frameworks.

1. Introduction

This study evaluates the authenticity, verifiability and alignment of Voluntary Carbon Offset (VCO) claims of programs offered by eighteen European airlines, aligning them with proposed EU regulations specifically targeting greenwashing practices.

VCO programs enable businesses and individuals to purchase carbon credits matching the amount of their estimated flight emissions that surpass the offset required of airlines, a concept known as offsetting. Research shows that the efficacy of VCO programs in genuinely mitigating international aviation emissions is increasingly doubted, not merely due to low participation and willingness to pay for carbon offsets but due to many other fundamental issues and inefficiencies intrinsic to their design and implementation (Mello, 2024). Compounding these challenges is the fact that the integrity of the carbon credits themselves, which are central to VCO programs, are under severe scrutiny (Calel et al., 2021; Guizar-Coutiño et al., 2022; West et al., 2020, 2023). The voluntary carbon market, reliant on a multi-step collaborative process, is characterized by ongoing debates over quality (Chen et al., 2021; Valiergue & Ehrenstein, 2023). Over 2011 to 2023, research consistently revealed that offset projects across all major sectors achieved considerably lower emissions reductions than originally claimed (Probst et al., 2023).

The European Union is advancing three pivotal regulations affecting carbon credits. The 'Green Transition Directive' took effect on Febru-

ary 28, 2024. The 'Certification Framework Directive,' focusing on a certification system for carbon removals, reached a provisional agreement following interinstitutional negotiations on March 8, 2024. The 'Greenwashing Directive,' aimed at ensuring transparent environmental claims, was adopted by the European Parliament on March 12, 2024, marking progress in the legislative process, though it has not yet been fully enacted.

The Green Transition Directive bans claims implying that a service or product has a neutral or reduced environmental impact due to carbon credit usage. Under the Greenwashing Directive, carbon credit claims, identified as compensation claims, are permitted exclusively for residual emissions. Additionally, the integrity of these claims must comply with the otherwise voluntary certification standards specified by the Certification Framework Directive.

These regulations may not directly impact VCO programs, where credits are purchased by passengers and businesses to offset non-mandatory flight emissions, rather than to reduce airline emissions. Within VCO programs, it is the purchasers, not the airlines, who claim the offsetting of emissions. Consequently, these claims are unrelated to the airlines' residual emissions and may fall outside the purview of the Certification Framework Directive's requirements.

The Greenwashing Directive defines greenwashing as the practice of making explicit, yet ambiguous or insufficiently substantiated, environmental claims about products or practices in business-to-consumer transactions. Furthermore, it sets forth criteria for substantiating en-

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vironmental claims, provides guidelines for their communication, and establishes verification procedures.

Greenwashing is an increasing concern in the aviation industry. On May 30, 2023, California residents filed a class action against Delta Airlines in the U.S. for falsely advertising itself as "carbon neutral." In March 2024, Fossielvrij NL sued KLM for using "sustainable" in campaigns and making inconsistent climate change claims. The District Court of Amsterdam ruled against KLM, making it the first airline judged for greenwashing. In April 2025, the European Commission investigated twenty European airlines for misleading green claims, such as suggesting air transport is "sustainable" and offering controversial carbon offsetting benefits. In March 2023, The Environmental Defenders Office, on behalf of Flight Free Australia, filed a complaint against Etihad Airways for false or misleading statements about greenhouse gas emissions and net-zero plans.

Given the significance of preventing greenwashing in VCO programs, along with their inherent complexities, there are growing concerns about the sufficiency of the EU regulatory proposals. Our research addresses two primary questions:

1. How effective is the Greenwashing Directive in both identifying greenwashing in VCO programs and communicating these findings to passengers in a comprehensible manner?
2. To what extent are airlines engaging in greenwashing practices and how do these practices align with the benchmarks set by the Greenwashing Directive?

This study transcends hypothetical discussions by examining the actual actions and strategies of these companies, thereby offering a clearer understanding of their operational impact on the environment. While air transport management research traditionally concentrates on competition and consolidation, and environmental research often addresses barriers to sustainability and business models (Wandelt et al., 2024), our study bridges the gap between regulatory and environmental research.

2. Literature review

Research on compensation claims in greenwashing is limited, especially for inherently harmful products like airline services (Neureiter & Matthes, 2023). Olk (2021) found that the closer the alignment between a traveler's ideal self-image and actual self-image with EasyJet's promise to offset carbon emissions, the higher the perception of authenticity of these efforts. Gurçam (2022) dismisses carbon offset programs as inadequate and primarily aimed at misleading consumers about the true environmental impact of flying, attributing much of the issue to neoliberal economic policies.

Tackling greenwashing in VCO programs fulfills two critical objectives. The first is ensuring consumer protection by providing accurate information in an environment characterized by significant information asymmetry. In contexts with prevalent information asymmetries 'green disclosures' can deceptively suggest positive social values (Bernini & La Rosa, 2023). Research across various studies paints a vivid picture of the information gap in public understanding of VCO programs. There is a widespread lack of depth in the public's grasp of VCO initiatives Aker et al. (2009) and Araghi et al. (2014), even among environmentally savvy consumers (Choi et al., 2016; Choi & Ritchie, 2014). This superficial understanding is further complicated by a notable gap where people's belief in the effectiveness of these programs often overshadows their actual knowledge about them (Barr et al., 2010a; Brouwer et al., 2008).

The second objective is preventing the spread of misinformation that could inadvertently promote non-sustainable behaviors. Research shows that environmental information is limited in nudging pro-environmental behavior (Hollenstein & Wittmer, 2024; Mello, 2024). However, if travelers are under the misconception that merely offsetting their carbon emissions is adequate to counteract the environmental impact of their flights, they might be less motivated to engage in more effective travel

sustainable practices. While the direct influence of misinformation on sustainable travel behavior has not been specifically studied, existing research does point to a trend where travelers show a preference for offsetting emissions over adopting more substantial changes in their travel habits (Baumeister et al., 2022; Gössling et al., 2009; Lee & Koo, 2020). Even environmentally conscious travelers are reluctant to adopt more sustainable travel habits persists even among environmentally conscious travelers (Barr et al., 2010b; Becken, 2007; McKercher et al., 2010).

Neureiter et al. (2024) and Neureiter & Matthes (2023) explain that compensation claims may not fit neatly into the most well-known categories of greenwashing. While vagueness involves using ambiguous language to obscure the true environmental impact, compensation claims involve concrete actions. Fibbing entails making false claims about a company's environmental practices, and hidden trade-offs highlight one environmentally friendly aspect while ignoring significant negative impacts. In contrast, compensation claims do neither; instead, airlines omit information about the significance of the impact. The authors show that concrete compensation claims do not increase perceived greenwashing compared to control condition, indicating that consumers do not perceive greenwashing in concrete compensation claims. However, individuals with high topical environmental knowledge perceived these claims as greenwashing to a greater extent than those with low knowledge.

Guix et al. (2022) investigate how airline VCO communications can be both misleading and trustworthy. While airlines are generally reliable in their VCO process and fact claims, the study identified greenwashing tactics on their websites, including obfuscation, unexplained jargon (vagueness), irrelevant information (irrelevance), and claims that divert attention from more significant environmental impacts (lesser of two evils).

3. Methodology

3.1. Analytical framework

Initially, we develop an analytical framework to highlight the critical components of explicit environmental claims within VCO programs. These claims, centered on carbon offsetting, diverge significantly from those arising from direct organizational actions aimed at reducing operational emissions in primarily two respects: their indirect nature and their lack of direct connection to the organization's primary business activities.

Emission reductions directly associated with the organization's products or services facilitate straightforward measurement and clear attribution to the organization's efforts. However, the assessment and verification of carbon credits entail a higher degree of complexity. This complexity stems from the challenge of evaluating the impact of projects beyond the organization's direct control, necessitating strict compliance with rigorous standards and the involvement of third-party verification to confirm their validity and effectiveness.

The analytical framework deconstructs the logical underpinnings of environmental offsetting claims, establishing four specific components or assumptions is conceptualized as a pyramid of logical assumptions (Fig. 1). If each of these foundational assumptions is met, the overall credibility of the claim is upheld. This structured approach allows for a systematic evaluation of the claims, ensuring that they are grounded in verifiable and coherent logical premises.

We then examine each specific assumption of the analytical framework through three phases:

1. Definition: First, we define the conditions under which the assumption is deemed satisfied and outline the benchmarks utilized for the specific assessment of these conditions in this study.
2. Comparative Frameworks' Assessment: Second, we assess how the Greenwashing Directive combined with the Certification Framework Directive, and academic frameworks compare to our analytical framework in detecting greenwashing. As a representation

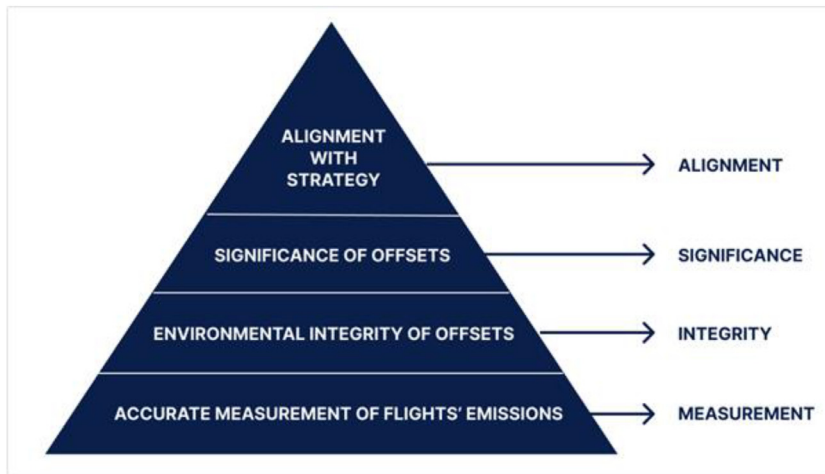


Fig. 1. Analytical framework.

of the state of the art in academic frameworks, we utilize the Nemes et al. (2022) framework. In the landscape of corporate environmental accountability, frameworks and regulations act as compasses for navigating the complexities of sustainability claims. The Nemes et al. (2022) framework is based on a detailed review and qualitative analysis of academic research literature, identifying various types of greenwashing and the indicators or questions used to detect its presence. It distinguishes itself by offering an actionable synthesis of academic research. This choice not only streamlines our analysis but also leverages the framework's practical applicability to our investigation.

3. VCO Programs: Finally, we conducted a thorough examination of the disclosures related to the eighteen VCO programs to identify how they align with the benchmarks of our analytical frameworks, the Greenwashing Directive combined with the Certification Framework Directive, and the Nemes et al. (2022) framework.

3.2. Data sources

The airlines studied include Air France, KLM, and Transavia (all part of the Air France-KLM Group), British Airways, Iberia, and Vueling (all part of the International Airlines Group-IAG), EasyJet, Finnair, Lufthansa, Air Dolomiti, Eurowings, and Austrian Airlines (all part of the Lufthansa Group), Norwegian Air Shuttle, Ryanair, Scandinavian Airlines (SAS), TAP Air Portugal, Turkish Airlines, and Wizz Air.

The core of our analysis is based on primary data sourced directly from the airlines. This includes information extracted from the official websites of each airline and, where applicable, their respective airline groups. We also analyzed data from annual reports and dedicated sustainability reports published by these airlines. Our focus was on publicly available information that directly pertains to the airlines' VCO programs.

To supplement our primary data, we gathered secondary data from reputable organizations such as the International Air Transport Association (IATA) and the International Civil Aviation Organization (ICAO). This included broader industry standards, emission data, and information on global carbon offset initiatives. This data provided a contextual backdrop against which the primary data was analyzed.

Utilizing self-reported data from airlines is essential in our analysis of VCO programs, due to the extremely limited availability of independent data in this area. While acknowledging the potential for bias in this data, it is important to note that such bias would not undermine the objectives of our research. Our study primarily focuses on evaluating whether the airlines' disclosures regarding the components of their VCO programs align with or diverge from established definitions

of greenwashing. These definitions are based on the specific frameworks we have selected for our research. Thus, the essence of our study is to critically assess the nature of these disclosures in the context of potential greenwashing practices, rather than the accuracy of the data per se. To mitigate potential biases in self-reported data, whenever the analysis of the greenwashing frameworks required it, we have benchmarked the airlines' disclosures against established industry standards.

4. Measurement

4.1. Definition and benchmarking

The measurement assumption is satisfied when the estimate of flights' emissions to be offset is deemed precise. However, as Baumeister (2017) points out, the process of estimating flights' emissions is technically complex and fraught with challenges. The mere disclosure of methodologies or their alignment with international standards may not suffice in curbing greenwashing or enhancing public understanding in the context of flight emissions estimates. The field is saturated with a multitude of international standards, and the use of proprietary methodologies, which amalgamate elements from these diverse standards, can often result in a semblance of substantiation. This "mixing and matching" of standards permits a wide-ranging interpretation and application of guidelines, potentially leading to claims that are technically substantiated yet devoid of substantial environmental impact. This scenario results in what can be termed as "empty substantiation," where the facade of technical compliance obscures the true efficacy and integrity of carbon offset initiatives.

Presenting absolute emission estimates in a form that passengers can easily understand remains a challenge. Research by Waygood and Avineri (2018, 2011) has shown that passengers often find it difficult to interpret CO₂ emission figures. Adopting simpler and more comprehensible methods to convey these data can significantly enhance public understanding and support more informed decisions regarding environmental impact.

To assess Measurement, we selected the ICAO carbon emissions calculator as a benchmark. This method has been extensively cited in numerous research studies and is known for its alignment with the reference values provided by the UK's Department for Environment, Food and Rural Affairs (Debbage & Debbage, 2019).

4.2. Comparative frameworks' assessment

The Nemes et al. (2022) framework emphasizes the need for clear, transparent, and accessible quantification of environmental impacts in

Table 1
Measurement component.

Airline	Discloses Emissions	Discloses Methodology	Discloses Results	Greenwashing Engagement Level
Air France	✓	✗	✗	⚠
KLM	✓	Proprietary	✓	⚠
Transavia	✗	✗	✗	⚠
British Airways	✓	✗	✗	⚠
Iberia	✓	✗	✗	⚠
Vueling	✓	✗	✗	⚠
EasyJet	✓	Southpole	✗	⚠
Finnair	✓	✗	✗	⚠
Lufthansa	✓	Myclimate	✗	⚠
Air Dolomiti	✓	Myclimate	✗	⚠
Eurowings	✓	Myclimate	✗	⚠
Austrian Airlines	✓	✗	✗	⚠
Norwegian	✗	ICAO	✗	⚠
Ryanair	✓	✗	✗	⚠
SAS	✗	✗	✗	⚠
TAP	✓	ICAO	✗	⚠
Turkish Airlines	✓	✗	✗	⚠
Wizz Air	✓	IATA	✗	⚠

Legend: ⚠ Low ⚠ Medium ⚠ High

claims (XI.1). It advocates for explicit specification, avoidance of technical jargon (XIII.1), and grounding in transparent methodologies (XI.4). Similarly, the Greenwashing Directive also focuses on clarity and detail in environmental impact disclosure. It stipulates the need for clear disclosure of targeted environmental impacts, mandates referencing an international standard, and requires a detailed disclosure of assessment methodologies, including their results, scope, assumptions, and limitations. However, both frameworks fall short in enabling effective comparability of environmental impacts. Both frameworks permit the “mixing and matching” of standards which risks leading to “empty substantiation.” The Greenwashing Directive, despite requiring the clear presentation of results, does not mandate adherence to a single, universally recognized benchmark for environmental impact assessment. This omission limits the comparability of reported environmental impacts, as disclosures based on different benchmarks or combinations thereof can lead to varied interpretations and evaluations of the same data.

4.3. VCO programs

As to the measurement component, most airlines are partially or fully engaging in greewashing practices (Table 1). Three airlines do not offer any data regarding estimated flight emissions. Among those that do provide these estimates, only eight airlines openly share their calculation methodologies. Within this subset, five airlines use proprietary techniques, whereas three adhere to methodologies sanctioned by international bodies like ICAO or International Air Transport Association (IATA).

When airlines utilize proprietary methodologies for flight emissions estimation, they typically provide an explanation of the methodologies, including their scope and assumptions and referencing international standards, but they generally lack transparency in presenting the actual

results of these calculations and do not comprehensively address potential limitations. A notable exception to this trend is KLM. This airline stands out by not only offering a detailed methodology based on actual flight data but also by openly disclosing a comprehensive table with the results for each flight segment. The tables clearly show the calculated CO₂ impact per passenger or per 100 kg of cargo for each departure and arrival airport, aligning closely with the directive’s requirements for full transparency.

To compare methodologies, we conducted simulations of approximately 30 flights of varying lengths for each airline, originating from their main hubs. These simulations enabled us to directly contrast the emission estimates provided by the airlines’ calculators with those generated by the ICAO calculator. We have found that Air France, Austrian Airlines, British Airways, Easyjet, KLM, and Ryanair consistently inform lower emission estimates for shorter flights compared to ICAO’s calculations, as evident in Figs. 2–7. British Airways, depicted in Fig. 4, presents a stark example: the shorter the flight, the greater the discrepancy between the airline’s estimates and those of the ICAO. These results are intriguing since shorter flights have higher specific fuel consumptions (Dahlmann et al., 2023), and route distance increases total CO₂ emissions and decreases emissions per ASK (Lo et al., 2020). While many variables can affect flight emissions, such a consistent disparity calls for a more in-depth investigation. Such inconsistencies underscore the importance of benchmarking airline emission data against an internationally recognized standard like that of the ICAO.

Additionally, the emission estimates from Austrian Airlines and Easyjet significantly exceeded ICAO’s figures. Easyjet’s methodology, for example, includes multipliers for ‘Well-to-Tank’ emissions and a Radiative Forcing Index multiplier, impacting their emission estimates. Adjusting these estimates to align with ICAO’s figures provided a closer comparison, as depicted in Figs. 3 and 5.

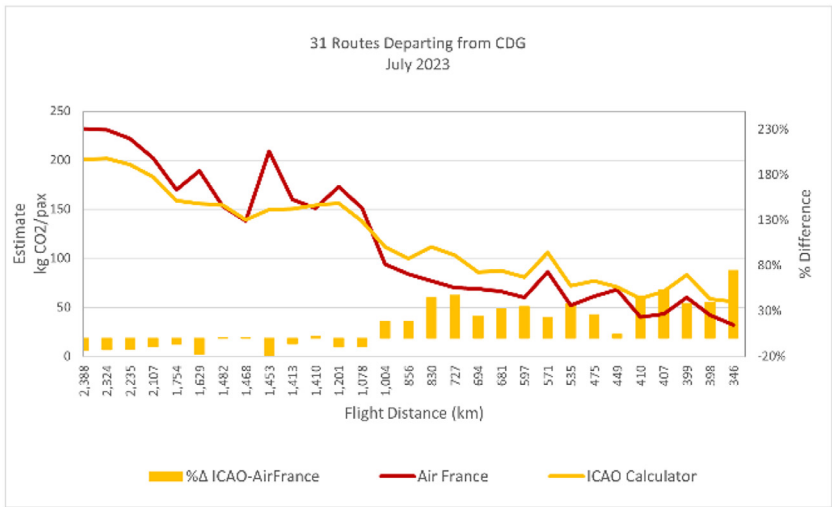


Fig. 2. Estimate emissions per passenger – Air France.

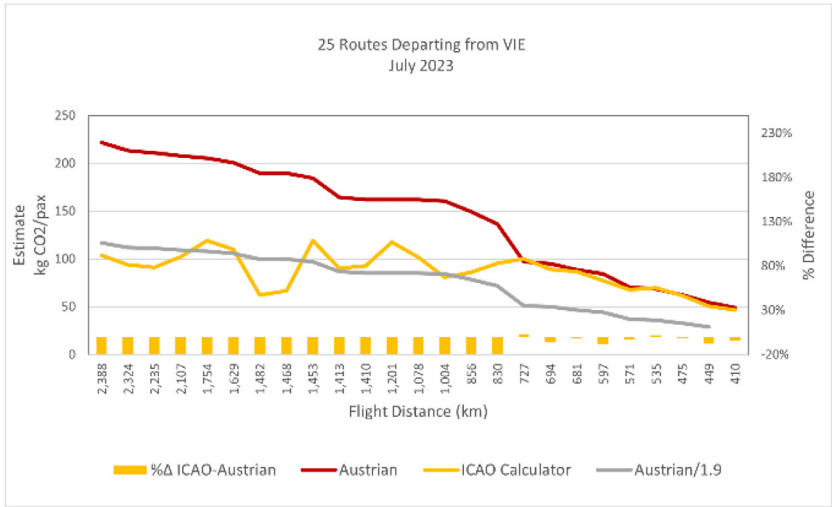


Fig. 3. Estimate emissions per passenger – Austrian Airlines.

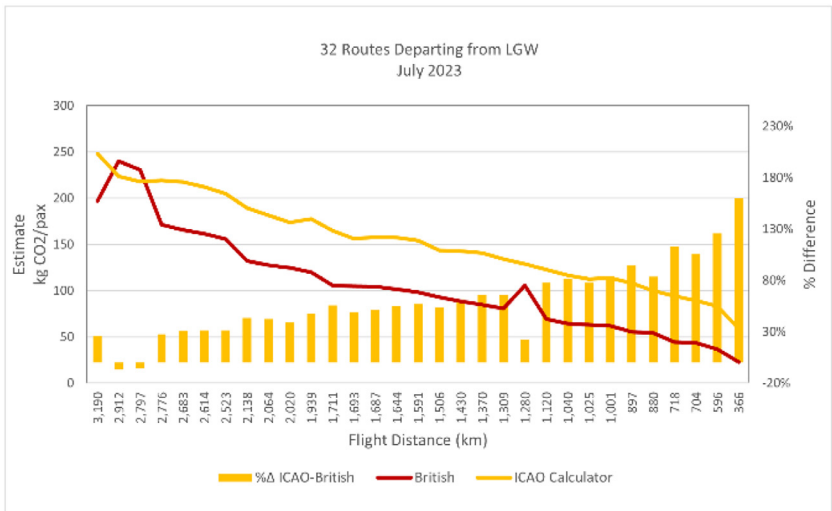


Fig. 4. Estimate emissions per passenger – British Airlines.

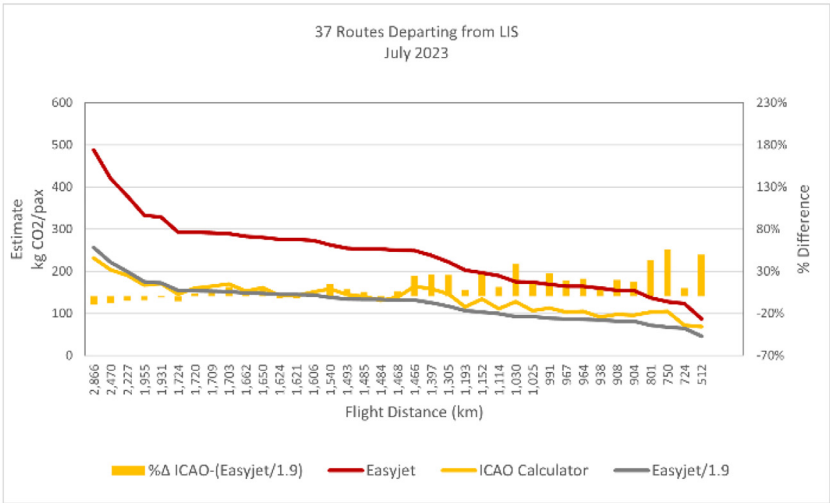


Fig. 5. Estimate emissions per passenger – Easyjet.

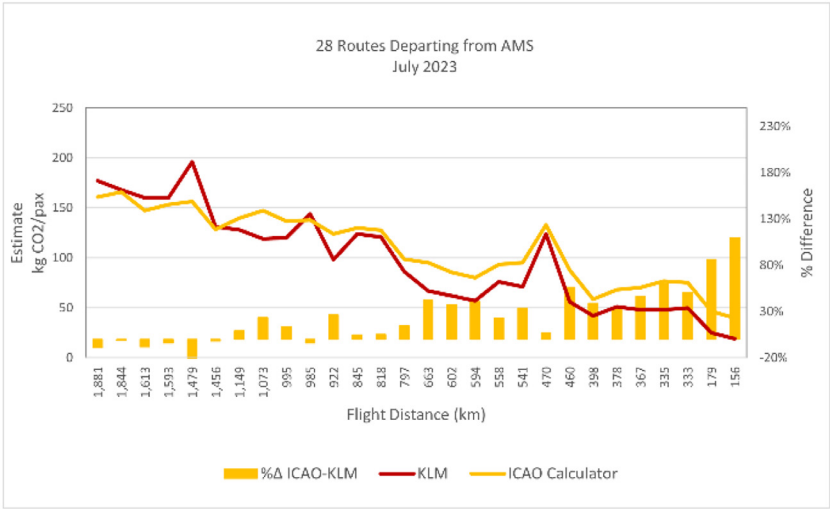


Fig. 6. Estimate emissions per passenger – KLM.

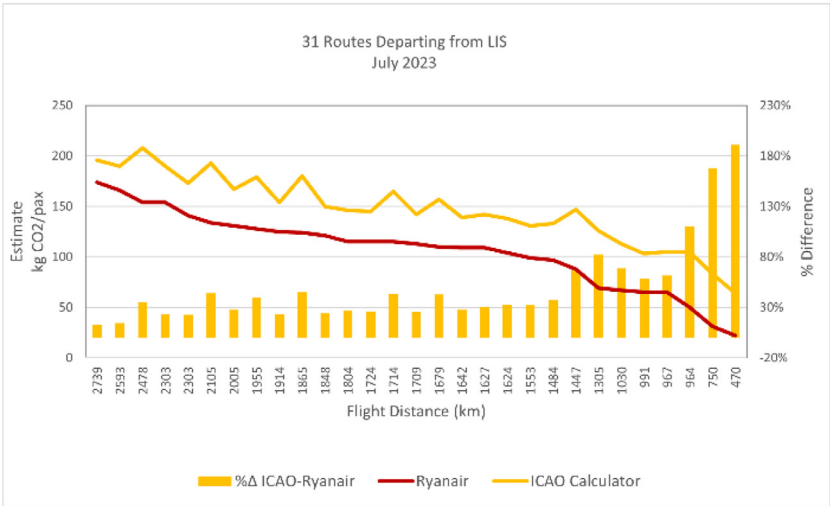


Fig. 7. Estimate emissions per passenger – Ryanair.

5. Integrity

5.1. Definition

The integrity assumption is satisfied when the authenticity of the carbon avoidance or reduction represented by the carbon credit is reasonably supported. The integrity of carbon credits is typically verified by certifications that adhere to various standards. However, the reliability of these standards varies significantly across organizations and sectors. For example, ICAO (2020) recognized credits from six standards for its CORSIA (Carbon Offsetting and Reduction Scheme for International Aviation) 2021–2023 pilot phase, recognizing challenges with widely accepted standards like VCS by VERRA and The Gold Standard, which represent a substantial share of the market (Chen et al., 2021).

Regulatory oversight plays a crucial role in ensuring the integrity of carbon credits, given that standard setters and certifiers are independent, non-regulated, non-governmental organizations. The proposed EU regulation is focused on ensuring integrity emissions of the traders, i.e. the airlines. But credits of a VCO program seem to evade its scope. The Certification Framework Directive provides a regulatory oversight to the integrity of carbon credits. However, its mandates apply specifically to offsetting claims aimed at reducing residual emissions as stipulated by the Greenwashing Directive. Outside of these circumstances, adherence to the Certification Framework Directive remains voluntary, which is the case of carbon credits utilized in VCO programs.

Carbon credit claims that fall outside the Certification Framework Directive cannot be asserted to directly improve environmental or climate impact of an airline; rather, they should be presented as additional environmental information. As previously noted, the claims in a VCO program are made by the clients of an airline, not the airline itself. Consequently, there is no specific provision preventing these customers from being led to believe that they are directly improving their own environmental impact, even though the overall context of the regulation indicates that this would be misleading.

To assess Integrity of carbon credits, in the absence of a regulatory framework applicable to VCO programs, we have chosen the CORSIA eligibility criteria as our benchmark for the integrity of carbon credits.

VCO programs are increasingly offering reductions through the use of SAFs, which do not result in the creation of carbon credits. The ICAO endorses two specific Sustainability Certification Schemes for CORSIA-compliant fuel economic operators: the International Sustainability and Carbon Certification (ISCC) and the Roundtable on Sustainable Biomaterials (RSB). These schemes have been authorized to certify operators adhering to CORSIA standards. In June 2023, ICAO certified nine batches of SAFs under its scheme (ICAO, 2023). ICAO has outlined distinct benchmarks for SAFs use under their CORSIA scheme (ICAO, 2022).

Conversely, the European Commission recognizes multiple standard schemes. This includes both voluntary schemes and national certification schemes established by EU countries, even those not specifically recognized by the Commission, provided the competent authorities in those countries vouch for the quality of the certification services.

To assess Integrity of SAF offers in VCO programs, we considered ICAO's approved schemes, specifically ISCC and RSB. This approach is influenced by the European Aviation Safety Agency (EASA) guidelines, which are focused on harmonizing aviation safety and environmental practices both within the EU and globally.

Our research, conducted in July and August 2023, examined environmental public disclosures, often reflecting the previous fiscal year. Hence, we have assumed SAF offers indicating compliance with the RSB or ISCC criteria are of high integrity, regardless of actual certification of the fuel batches. On the other hand, airlines that have only named a specific SAF supplier are regarded as being in partial compliance. This classification acknowledges their effort in sourcing SAF from credible and responsible suppliers. However, without the full scope of ISCC or RSB certification, there remains a degree of uncertainty regarding the complete adherence to the highest sustainability standards.

5.2. Comparative frameworks' assessment

The Nemes et al. (2022) suggests that organizations conduct due diligence on certification schemes to verify the authenticity of their claims (item VII.3). In the context of airlines, this translates to the responsibility of ensuring the integrity of certified credits. Initially, the Greenwashing Directive proposed a similar requirement, yet the European Parliament's first-reading position has since omitted this provision. Consequently, carbon credits intended for offsetting residual emissions now unequivocally fall under the integrity requirements mandated by the Certification Framework Directive. Conversely, carbon credits utilized by passengers for offsetting non-mandated emissions, or by individuals aiming to compensate for their activities, are not subjected to these integrity standards.

Conversely, according to the Greenwashing Directive, emissions reductions resulting from SAF utilization must be supported by international standards and there are clear standards for SAF certification approved by the EC.

5.3. VCO programs

Regarding carbon avoidance and carbon removal projects, integrity is still an issue. Table 2 provides a synthesis of the alignment of airlines with the integrity component across their various project offerings. Among the airlines assessed, eight received a 'Partial' rating for their vulnerability to greenwashing. Only TAP demonstrates full integrity across its project offerings, although it has a limited number of projects compared to others.

Out of the airlines reviewed, all specify their supported projects, with the exceptions of KLM and Transavia. Austrian Airlines is another unique case, as its contributions go toward the portfolio of ClimateAustria. This portfolio encompasses a vast array of both domestic and international projects, but these were not identified on an individual basis. Excluding those under ClimateAustria and those from KLM and Transavia, a total of 32 projects supported by the VCO programs were individually identified and scrutinized.

While many airlines are transparent about their supported projects, there is often less clarity when it comes to the distribution of funds among these initiatives. When multiple projects are supported, programs do not disclose the breakdown of how funds are distributed among them. In certain programs, the third-party provider even retains the option to substitute a project for another of matching price and quality. EasyJet and Turkish Airlines are exceptions: for each passenger's contribution, their programs specify the exact allocation to the chosen project or portfolio of projects.

Out of the 32 projects examined, only half, precisely 16 projects, successfully meet the criteria for inclusion under the CORSIA scheme. A notable observation is that 4 of these projects are either uncertified or only comply with regional standards, and 2 projects remain unidentified at this stage. Among the 29 projects that are registered with either the Verified Carbon Standard (VCS) or Gold Standard (GS), a significant portion, amounting to 10 projects, do not align with the inclusion criteria set by the CORSIA scheme.

Austrian Airlines, Eurowings, Lufthansa, and Ryanair have chosen to support projects that might not have international certification but hold regional significance, being located within the communities they serve. Austrian Airlines relies on ClimateAustria, which assesses projects according to Austrian financial support guidelines. Meanwhile, projects backed by Eurowings and Lufthansa undergo evaluation by myclimate. Ryanair's initiative is a collaboration with the National Forestry Conservation Institute in Portugal. While all these projects undergo some form of oversight, they may not conform to international standards eligible to regulated schemes. As a result, their verifiable impact as offset claims might be debated in a broader, global context. If the airlines had chosen to invest their own funding in the projects as a separate community initiative, distinct from the passengers' contributions, accountability for the representation made to the passengers as to offsetting would not be

Table 2
Integrity of carbon avoidance and removal projects.

Airline	# Avoidance Projects	# Removal Projects	# CORSIA Eligible	Greenwashing Engagement Level
Air France	0	0	0	🟢
KLM	Not specified	0	0	🔴
Transavia	Not specified	0	0	🔴
British Airways	1	1	0	🔴
Iberia	2	0	0	🔴
Easyjet	3	0	2	🟡
Finnair	2	0	0	🔴
Lufthansa German	7	0	4	🟡
Air Dolomiti	7	0	4	🟡
Eurowings	7	0	4	🟡
Austrian Airlines	Not specified	0	0	🔴
Norwegian	4	0	1	🟡
Ryanair	4	0	3	🟡
TAP	1	0	1	🟢
Turkish Airlines	6	0	4	🟡
Vueling	0	1	0	🔴
Wizz Air	2	0	1	🟡
SAS	0	0	0	🟢

Legend: 🟢 Low 🟡 Medium 🔴 High

Table 3
Integrity of SAF offers.

Airline	Names Supplier	Mentions RSB Certification	Greenwashing Engagement Level
Air France	✖	✔	🟢
KLM	✖	✔	🟢
British Airways	Phillips 66	✖	🟡
Finnair	Neste	✖	🟡
Lufthansa German	✖	✔	🟢

Legend: 🟢 Low 🟡 Medium 🔴 High

an issue. Such an investment would exemplify the airlines' voluntary corporate social responsibility efforts, underscoring their dedication to environmental conservation and independent support for the local community, regardless of the VCO program.

British Airways and Vueling have implemented carbon removal projects that adhere to the Puro Earth methodology. On February 2024, Puro Earth announced it had aligned its rules with those of CORSIA and it aimed at applying for eligibility.

Regarding SAF offers, it is significant that airline disclosures on the integrity of these offers predominantly reference ICAO schemes rather than any specific European Commission scheme. This prevalent industry practice underscores the correctness of our decision to adhere to ICAO standards such as ISCC and RSB.

In summary, regarding the integrity component, it is evident from Table 2 that a majority of airlines are either partially or fully engaged in greenwashing practices concerning their carbon avoidance and carbon

removal offers. Conversely, as shown in Table 3, the integrity of SAF offers is notably higher. This contrast underscores the persistent challenge in ensuring the integrity of carbon credits, a concern that remains despite over a decade of implementation of these initiatives.

6. Significance

6.1. Definition

The Significance assumption is satisfied if the offset activities have tangible, quantifiable impact in the carbon mitigation efforts of an airline. Absent clear and measurable environmental benefits, a VCO program risks being perceived as a superficial endeavor rather than a substantive contribution to ecological conservation.

To assess Significance, we examined whether the airlines annually disclosed their uptake rates and the total emissions offset. The absence

of consistent disclosure regarding the annual emissions offset is a telling indication of the VCO program's priority within the airlines' operational hierarchy. If mitigating emissions were a pivotal component of their corporate responsibility, then one would anticipate transparent communication of their achievements. If data remains conspicuously under-reported, one can conclude that the success of these VCO programs in reducing emissions is not deemed critical by the airlines.

6.2. Comparative frameworks' assessment

According to item (II.3) in the Nemes et al. (2022) framework, greenwashing is identified by the absence of significant and measurable environmental impact from the initiative. Likewise, the Greenwashing Directive explicitly requires assessments that demonstrate the significance of environmental impacts from a life cycle perspective.

When claims are associated with an airline's emissions reductions, their significance is clearly linked to the airline's operational activities. However, in claims made within VCO programs, where the emissions reductions are not directly tied to the airline's activities, the parameters for assessing significance are less clear. VCO programs often assign emissions responsibility to passengers, particularly when their contributions surpass the mandatory offsets required in regulated schemes. Labeling passenger compensation claims as significant in relation to their individual emissions can lead to these claims being viewed as highly impactful, considering that emissions from a single flight generally surpass those from many other personal activities. Yet, this viewpoint risks incorrectly attributing the source of emissions to passengers, rather than recognizing them as stemming from the airline's operations.

This misattribution is pivotal, especially considering the nuanced nature of how significance is perceived by passengers and its subsequent impact on their behavior. For instance: a higher offset percentage increases participation, yet perceived benefits decrease when collective uptake surpasses 50 %, (Mello, 2024). Therefore, it is essential to communicate the significance of emissions offsets effectively, not solely in terms of individual passenger contributions but also within the wider context of collective environmental efforts.

Another challenge arises from the methodology used to calculate the environmental impact. According to the Greenwashing Directive, this assessment must encompass the entire operational life cycle of the airline. Flight emissions methodologies, including those used in tools like the ICAO calculator, do not necessarily follow a life cycle methodology. Life cycle methodology encompasses the entire life cycle of a product or service, from production to disposal, whereas flight emissions methodologies typically focus on the emissions generated during the flight itself, not taking into account the full life cycle of the aircraft, fuel production, and other related factors. Therefore, the proposed EU regulation does not align with the current industry practices in VCO programs.

The proposed EU regulation mandates detailed disclosures regarding the measurement of environmental aspects, impacts, and performance. However, it lacks specificity on the frequency of updates, a crucial factor for ongoing initiatives. While the directive requires updates every five years or when changes impact accuracy, specifying annual updates for ongoing initiatives could provide greater clarity and consistency.

6.3. VCO programs

Norwegian and Lufthansa are the only airlines that annually disclose both their program's uptake rate and total emissions offset. Norwegian's uptake rate decreased from 2.7 % to 1.8 % between 2021 and 2022, offsetting 40ktCO₂, which is 2.7 % of their Scope 1 emissions. In contrast, Lufthansa Group witnessed an uptake increase from less than 1 % in 2022 to 3 % in 2023, with customer offsets rising consistently: from 20 ktCO₂ in 2020, to 65 ktCO₂ in 2021, and further to 380 ktCO₂ in 2022.

Other airlines that reported any measures include KLM, with an uptake exceeding 10 % in 2022; Ryanair, disclosing a static 3 % uptake rate since its program began; and Finnair, which reported customer-offset

emissions at 3.4ktCO₂, equating to 0.14 % of their Scope 1 emissions for the year 2022.

Despite the limited participation in these programs, it appears that most airlines are not actively focusing on increasing engagement. While the primary access point for passengers to VCO Programs is through the booking platform, nine airlines offer VCO programs through third-party platforms, which are not prominently featured during the booking process. These airlines include British Airways, Iberia, Vueling, EasyJet, Finnair, Norwegian, Turkish Airlines, and Wizz Air. It seems that these third-party platforms primarily serve passengers who are already well-informed about and interested in offsetting. This is intriguing because research reveals two important insights: first, travel frequency was not a significant predictor of awareness. Instead, factors such as ticket price, environmental interest, regular donations, and academic degrees were positively correlated with VCO program awareness (Segerstedt & Grote, 2016). Second, individuals who adopt pro-environmental behaviors in various aspects of their lives often extend these practices to air travel and generally hold a more positive attitude toward offsetting (Mello, 2024).

Notably, Lufthansa Group airlines, which witnessed a growth in engagement, provide offsets through their VCO programs and also integrate them into their Green Fares. This approach is noteworthy because it broadens the possible interfaces where the passengers can offset and effectively and creatively complies with the EU's prohibition on opt-out schemes. The support for the adoption of VCOs is significantly higher when presented as a choice to reject a payment (opt-out) rather than a choice to make a payment (opt-in) (Mello, 2024). The EU's Consumer Rights Directive (2011/83/EU) underscores the importance of consumers actively selecting and expressly consenting to any additional options. Research has shown that support for the adoption of VCOs is notably higher when presented as a choice to reject a payment (opt-out) rather than a choice to make a payment (opt-in) (Araña & León, 2013; Eslaminassab & Ehmer, 2022). This model faces potential challenges under the Greenwashing Directive. The restrictions on environmental claims based on carbon credits would require the airline to reframe its Green Fare offer.

In summary, the current landscape raises questions about the potential greenwashing aspect of VCO programs. Not only do these programs have limited measurable impacts, but they have also been in place for more than a decade, which adds to the scrutiny of their effectiveness. Moreover, airlines seem to be making little effort to enhance engagement or demonstrate significant contributions to environmental sustainability.

7. Alignment

7.1. Definition

The Alignment assumption is satisfied if VCO initiatives are congruent with an airline's overarching environmental strategy and advocacy efforts.

Greenwashing, fundamentally, entails the deceptive signaling of environmental responsibility. While it can stem from unsubstantiated claims, its scope extends beyond mere falsehoods. (de Freitas Netto et al., 2020) note that greenwashing is often evident in the disparity between a company's environmental claims and its wider business conduct or advocacy. This misalignment, evident even when the claims are substantiated, points to a deeper issue beyond factual accuracy, suggesting a company's strategic use of environmental rhetoric that does not reflect its actual practices.

In our analysis, we have exclusively assessed the internal alignment of VCO programs with the airlines' environmental policies. First, we checked if airlines mentioned their VCO programs in their environmental strategy documents. Second, we analyzed how these programs were described, focusing on the specific role attributed to them within the broader environmental framework. Finally, we looked for explicit goals

set by the airlines for their VCO programs, determining whether these initiatives were supported by clear, targeted objectives.

7.2. Comparative frameworks' assessment

The Nemes et al. (2022) framework suggests that claims that do not reflect consistent environmental practice are indicative of greenwashing (item VI). As to the Greenwashing Directive, strategic alignment falls outside its scope.

7.3. VCO programs

We have noted that VCO programs carry strategic significance for airlines, which extends beyond their measurable environmental impact. Airlines strategically leverage these programs for reputational management, albeit without a direct link to comprehensive environmental objectives. This is evident in the ambiguous integration of VCO initiatives within the airlines' broader environmental strategies, and the absence of specific, measurable commitments or targets in the VCO programs that align with the organizations' wider sustainability goals.

Only a limited number of airlines acknowledge the role of VCO Programs in their environmental initiatives. The AirFrance-KLM group, the IAG group, Ryanair, and Turkish Airlines explicitly declare that VCO programs are established to tackle reputational risks and strategically address passengers' concerns about aviation's impact on climate change. Turkish Airlines' program underscores its reputational intent: its industry-wide approach offers benefits to passengers of any airline, seeking to decouple the association between air travel and emissions.

Lufthansa Group and SAS stand out in their distinct approaches within the airline industry. Lufthansa highlights the importance of economic measures for climate protection, acknowledging the current limitations in the availability of SAF and advanced propulsion technologies, and has set a specific target of 5 % participation in their VCO program supply. Meanwhile, SAS effectively integrates its VCO Program into its sustainability strategy. Operating under Chapter 11 bankruptcy protection, SAS emphasizes the significant role of passenger contributions, having successfully utilized 3083 tons of SAF in 2022.

TAP's changes in ownership and environmental strategies over the years have provided an intriguing case study of the interplay between stakeholder influence and corporate sustainability policies. Up until 2015, TAP disclosed the total emissions yearly offset by the VCO. More significantly, it established quantitative targets for each year of the program's operation and compared the program's performance against these goals. From 2016 to 2019, TAP did not produce standalone sustainability reports, nor did it include a separate sustainability section in its annual reports. This shift in reporting practices coincided with changes in the company's ownership structure. The resumption of TAP's sustainability reporting under majority government ownership in 2020 was a significant development, but the newer reports no longer offered detailed information on measurable results and the disclosure of total emissions offset by the VCO program,

EasyJet highlights its offsetting strategy as a means to address reputational risks. The airline emphasizes a growing awareness among its customers regarding sustainability and flying, particularly around offsetting. The airline promotes and monitors awareness of its environmental strategy. In October 2021, 56 % of its customers were aware of the airline's policy to offset all emissions, including those not mandated by regulation, 27.1 % considered the environmental impact on their future flight decisions, and 37.5 % were influenced by an airline's carbon offsetting efforts in forming their decision. EasyJet has discontinued this policy in December 2022. Since January 2023, the airline allows its passengers to offset emissions themselves. However, the link to the third-party platform is not presented during the booking process, potentially allowing the airline to maintain its eco-conscious reputation among passengers unaware of the change.

Whilst the other studied airlines do not overtly mention the intention to address reputation risks with the VCO program, they are likely involved in adopting a mimicking approach not to be put at a competitive disadvantage. Wizz Air, for instance, maintains a VCO program even though it affirms that "although there are some verified voluntary offsetting schemes out there (like the carbon offsetting service we offer to our customers via our partner CHOOOSE), we do not believe that this option by itself provides a long-term solution for aviation to achieve net zero emissions by 2050" (Wizz Air, 2022).

8. Additional findings

8.1. CO₂ cost per tonne to the consumer

Neither academic frameworks, nor the Greenwashing Directive require disclosure of offset costs. However, disclosing them enhances transparency and accountability in VCO programs, providing a measure for evaluating an airline's environmental commitment. While not a direct indicator of effectiveness, cost transparency helps prevent superficial claims, requiring airlines to offer tangible, assessable data. Coupled with other information like offsetting methods, environmental impact, and alignment with sustainability goals, cost details contribute to a fuller understanding of a program's efficacy and help prevent greenwashing.

On November 2022, the average EU-ETS auction price for aviation was €74.25/tCO₂e (EEX, 2022), indicating a strong regulatory push for direct emission reductions. In contrast, the volume-weighted average price for CORSIA eligible projects was USD\$9.46/tCO₂e (Ecosystem Marketplace, 2023), with varied costs for avoidance and removal projects in VCO programs and significantly higher costs for SAFs (Table 4). This disparity highlights the aviation industry's dilemma: current technologies and efficiency improvements are insufficient to significantly reduce GHG emissions (Lai et al., 2022). Although emerging technologies like SAFs offer future potential, the immediate and viable strategy for mitigating aviation emissions currently lies in offsetting.

This data underscores a critical point for social and regulatory pressure for substantial emissions reductions from airlines. The high costs of SAFs limit the airlines' ability to implement these sustainable options on a large scale due to economic constraints. Meanwhile, the preference for VCO programs, despite their limitations, becomes a more feasible alternative. This situation reflects the challenging balance between advancing sustainable aviation practices and the technological and economic realities of the industry. It also highlights a paradox: while there is a call for reduced emissions, there is also a general reluctance among passengers to fly less, further complicating the path to significant emissions reduction in aviation.

8.2. Transparency enhancements in the greenwashing directive

The Greenwashing Directive enhance transparency, particularly by mandating that substantiating elements accompany claims in physical or digital forms. However, VCO program data is scattered across various sources like annual reports, environmental reports, press releases, and websites, without a standardized format. This diversity, ranging from text documents to interactive webpages, complicates data extraction and comparison. Additionally, these regulations require organizations to provide a consumer-friendly summary of the substantiation assessment in the language of the claim. Notably, the depth of environmental disclosures varies by language, with non-English versions often being more detailed.

Requirements of the Greenwashing Directive will also improve clarity of airlines' offer of offsets via SAF procurement. Under the Greenwashing Directive, claims should surpass legal requirements. However, only Air France (Air France, 2023) and SAS (SAS, 2021) explicitly state their commitment to procuring SAF beyond what is legally required.

Furthermore, the directive mandates specific, time-bound commitments for future environmental performance within organizational op-

Table 4
Cost per tonne (passenger) – one-way economy direct flights.

Airline	€/tCO ₂ Avoidance	€/tCO ₂ Removal	€/tCO ₂ SAF
Air France			726.19
KLM	16.51		728.92
Transavia ³			
British Airways ¹	20.37	63.44	239.48
Iberia	12.96		
Vueling		120.69	498.23
Easyjet ²	8.80		
Finnair	26.56		753.18
Lufthansa German/Air Dolomiti/Eurowings	15.52		768.00
Austrian	15.50		731.80
Norwegian	11.25		
Ryanair	24.00		
SAS			521.89
TAP	11.33		
Turkish Airlines ⁴	20.00		
Wizz Air	12.51		

¹ Conversion rate used: £1.00 = €1.17. For every increase of 1 ton of CO₂, the SAF values decrease by €0.08.

² Value corresponds to the Wind project. Reforestation at €10/tCO₂, Cookstoves at €14.50/tCO₂.

³ Transavia lacks a carbon calculator. Offset values for a sample of 3 routes departing from Amsterdam ranged from €0.89 to €3.93.

⁴ Value corresponds to the “Renewables” package. “Greener” at €24/tCO₂, “Community” at €28/tCO₂. Source: The cost per tonne for all airlines, except KLM, was derived from a simulation of approximately 30 flights of varying distances. For each flight, we calculated the value per tonne and subsequently determined the overall average. Generally, values per tonne showed only minimal variation across flights. An exception to this was SAS, which exhibited significant variability in its values, with a range of €490.

erations and value chains. Among SAF-offering airlines, only British Airways (British Airways, 2022; Chooose, 2023), Lufthansa Group (Lufthansa Group, 2022b), and SAS (SAS, 2021) have set clear utilization deadlines for these funds.

8.3. Increasing adoption of corporate offers

Historically, VCO programs were designed with individual passengers in mind. Yet, recent trends underscore a pivot towards corporate clients. Air France-KLM's Corporate SAF program parallels their VCO initiatives for individual passengers. Both British Airways and the airlines under the Lufthansa Group umbrella cater their programs to individual passengers and corporate clients alike. By the close of August 2023, Iberia has shifted its focus to serve exclusively corporate clients.

These offers have become popular because European corporations face escalating demands to achieve net-zero emissions. The European Green Deal aims for a climate-neutral status by 2050. This vision is further supported by potential legal commitments under the prospective Climate Law, which seeks to make it binding for the EU to achieve net-zero emissions by 2050. In tandem, the Sustainable Finance Disclosure Regulation (SFDR) requires financial entities to be transparent about their environmental impact, indirectly molding corporate emission goals. On a more localized level, countries such as the UK, France, and Germany have instituted their distinct binding targets and regulations.

Emissions resulting from employee business travel fall under the Scope 3 category. Carbon credits can potentially be used to offset these emissions. Per the Lufthansa Group, using their proprietary method, even emissions reductions resulting from SAF procured by the group with proceeds from the program (Scope 1) can be reassigned to their customers (Scope 3) (Lufthansa Group, 2022).

The growing trend of offering VCO programs to businesses has underscored the significance of dedicated program platforms. Corporate VCO programs provide businesses with monthly emissions breakdowns,

streamlining their non-financial reporting obligations. This responsibility has its roots in the EU's 2014 Non-Financial Reporting Directive (NFRD), which evolved into the Corporate Sustainability Reporting Directive (CSRD) in 2023. As a result, not only large corporations but also listed small and medium-sized enterprises are now tasked with delivering detailed reports on sustainability matters.

Airlines are also leveraging VCO program platforms to create marketing and customer loyalty initiatives. This burgeoning trend underscores a pressing need for bolstering the integrity of credits within VCO programs, both in the context of the airline sector and beyond. While some credits offered under these programs might not possess the necessary integrity guarantees to offset airlines' emissions in the industry's regulated settings, they still find relevance in offsetting the Scope 3 emissions of corporate customers.

Under the Greenwashing Directive, claims of emissions reductions via carbon credits are restricted to residual emissions, awaiting clarification through a delegated act post-directive enactment, leaving the inclusion of Scope 3 emissions uncertain. Credits used for these claims must meet the Certification Framework Directive's integrity standards, excluding carbon avoidance initiatives. Should residual emissions be defined without encompassing Scope 3, this could deter business engagement in VCO programs, as the directive's limitations on claims and the uncertain status of Scope 3 emissions could impact the attractiveness and perceived relevance of these programs for corporate clients.

9. Conclusion

In this article we have shown that European airlines are engaging in greenwashing practices in their VCO programs (Table 5). It is important to underscore that neither this research nor the Greenwashing Directive, combined with the Certification Framework Directive, ascribes malicious intent or deliberate deception to organizations involved in practices potentially perceived as greenwashing. They simply recognize that these practices exist in the market and may mislead consumers.

Table 5
Greenwashing Engagement Level.

Group	Airline	Greenwashing Engagement Level				
		Measurement	Integrity		Significance	Alignment
			Carbon Credits	SAF		
AirFrance-KLM	Air France	⚠️	✅	✅	⚠️	⚠️
	KLM	✅	⚠️	✅		
	Transavia	⚠️	⚠️	na		
IAG	British Airways	⚠️	⚠️	⚠️	⚠️	⚠️
	Iberia	⚠️	⚠️	na		
	Vueling	⚠️	⚠️	na		
Easyjet	EasyJet	⚠️	⚠️	na	na	⚠️
Finnair	Finnair	⚠️	⚠️	⚠️	⚠️	⚠️
Lufthansa	Lufthansa German	⚠️	⚠️	✅	✅	✅
	Air Dolomiti	⚠️	⚠️	na		
	Eurowings	⚠️	⚠️	na		
	Austrian Airlines	⚠️	⚠️	na		
Norwegian	Norwegian	⚠️	⚠️	na	✅	⚠️
Ryanair	Ryanair	⚠️	⚠️	na	⚠️	⚠️
SAS	SAS	⚠️	✅	na	⚠️	✅
TAP	TAP	✅	✅	na	⚠️	⚠️
Turkish Airlines	Turkish Airlines	⚠️	⚠️	na	⚠️	⚠️
Wizz Air	Wizz Air	✅	⚠️	na	⚠️	⚠️

Legend: ✅ Low ⚠️ Medium ⚠️ High

The most compelling evidence of greenwashing lies in the insignificance and misalignment of the VCO programs, indicating that these initiatives are implemented without any substantial impact on the airlines' mitigation efforts and are not integrated into their overall strategies. This finding is crucial as it moves the discussion of VCO programs beyond the prevalent criticism of lacking integrity. Irrespective of their integrity, these programs mislead consumers into believing they are making a significant contribution to sustainability.

These issues are not adequately addressed by the Greenwashing Directive. Misalignment falls outside its scope, and the significance parameters in VCO programs remain unclear because the claims are often attributed to the passengers. This misattribution can lead passengers to believe their contribution is more impactful relative to their own emissions, whereas it should be assessed in relation to the airlines' overall emissions. Furthermore, the directive mandates significance disclosures every five years, whereas these programs should ideally disclose their performance annually to ensure transparency and accountability.

The example of the Lufthansa Group illustrates that greenwashing can be significantly mitigated when sustainability strategies are thoughtfully designed and integrated, rather than comprising a patchwork of isolated green initiatives. While the level of impact necessary

to achieve significance is inherently subjective and the effectiveness of these programs within the mitigation efforts of the Lufthansa Group can be debated, the group has successfully tracked and disclosed its achievements. Regardless of the size of the contribution, aviation sustainability is a complex issue that requires a portfolio of solutions. This suggests that the issue may stem from the need for skillful management and strategic planning, rather than merely adopting tools and practices in a superficial or uncoordinated manner.

The Greenwashing Directive represents a notable step forward in promoting enhanced transparency within the environmental sector, demonstrating a robust congruence with the academic framework. However, it falls short in identifying greenwashing in VCO programs and communicating these findings to passengers in a comprehensible manner.

The Greenwashing Directive could benefit from more explicit provisions aimed at improving the comparability of environmental impacts in the aviation industry. The purpose of the regulation is not necessarily to provide precise measurements of impact, but rather to promote mitigation efforts, which are much more effective when there is comparability. A relatively straightforward issue to address is the regulation of an international methodology to calculate flight emissions. The directive currently relies on the life cycle approach, which, despite its compre-

hensiveness, diverges from current industry practices. Implementing a sector-wide benchmark would streamline the evaluation of environmental claims, making it simpler for consumers to understand and compare the environmental efforts of different airlines.

Airlines utilize a variety of methods to calculate flight emissions for offsetting purposes, but these methods are often shrouded in non-transparency and marked by inconsistency. Introducing a mandatory sector-specific benchmark, such as the ICAO calculator, whose results would accompany each claim, could significantly enhance comparability. By standardizing the basis on which claims are made, even in instances where airlines rely on proprietary methodologies or a combination of different standards, this approach would facilitate straightforward comparisons across the sector. Moreover, it would offer a more practical alternative to the life cycle approach.

The Certification Framework Directive would also benefit from including carbon avoidance credits in its scope. The Integrity of credits in VCO programs is still a relevant issue. The mandate within the Greenwashing Directive that emission reduction claims comply with the Certification Framework Directive, while simultaneously excluding carbon avoidance credits from this directive, has two important consequences. The first is that the carbon credit market may potentially divide into segments with differing integrity and price sensitivity. VCO programs may cater to lower integrity, more affordably priced carbon credits.

The second consequence is that EU airlines participating in CORSIA will have to navigate through eligibility challenges. One example is the divergence in the recognition of carbon avoidance activities between the two systems. CORSIA's acceptance of carbon avoidance credits allows for a broader spectrum of projects to be eligible for generating carbon credits, including renewable energy projects like windmills and biochar cookstoves. In contrast, the Certification Framework Directive focuses exclusively on activities that directly remove carbon dioxide from the atmosphere and store it. This approach excludes a range of carbon avoidance projects that could otherwise contribute to emission reduction efforts. For EU airlines, this discrepancy means navigating two sets of criteria for offsetting emissions under CORSIA and for participating in EU-based carbon reduction efforts.

A final impact of the new regulations could be a reduction in corporate engagement in VCO programs. The Greenwashing Directive stipulates that emission reduction claims using carbon credits are limited to offsetting residual emissions. This could potentially diminish corporate participation in VCO programs, especially if the pending definition of residual emissions excludes Scope 3 emissions.

10. Limitations and future research

This study exhibits several limitations, particularly concerning the research methods employed. A significant limitation is the reliance on self-reported data from airlines, which is susceptible to bias and a lack of transparency. While this reliance is necessitated by the scarcity of independent data, it inherently raises concerns regarding the accuracy and completeness of the information provided. Additionally, the variability in data presentation and quality across different airlines further complicates the assessment. Specifically, not all airlines disclose comprehensive information, leading to incomplete data sets that hinder effective analysis. Moreover, the inconsistency arises from the fact that some airlines employ proprietary methodologies for estimating flight emissions, while others adhere to internationally recognized standards such as those established by the ICAO or the IATA.

Future research should investigate the extent to which carbon avoidance credits contribute to sustainability efforts and innovation and how to fund them. While it is essential to address concerns regarding the integrity of these credits, it would be premature to dismiss their potential positive impact outright. Carbon avoidance credits have the potential to catalyze the implementation of initiatives that might otherwise remain stagnant due to financial constraints.

Another essential area for further exploration lies in gaining a deeper understanding of the intricate processes and decisions that underlie greenwashing practices. The term often carries connotations of deliberate deception, potentially misrepresenting the nuanced reality of its origins. Rather than solely stemming from intentional deceit aimed at consumers, greenwashing can arise from a multitude of circumstances and motivations. In industries such as aviation, where technological advancements have yet to fully align with the imperative for emissions reductions, greenwashing may emerge as a reactionary response to mounting environmental pressures. Additionally, instances of strategic misalignment with environmental initiatives might stem from procedural deficiencies within organizations rather than deliberate attempts to deceive.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

CRedit authorship contribution statement

Mello Fabiana Peixoto de: Writing – review & editing, Writing – original draft, Visualization, Validation, Software, Resources, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization. **Macario Rosario:** Supervision.

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