Insights 2025

July 2025

impact
ON SUSTAINABLE AVIATION

Content

Introduction 3

The sustainable aviation journey: insights from the ISTAT/impact Sustainability Symposium 5

impact Webinars 8

2024 commercial aviation emissions grow above 2019 levels 10

Willis Sustainable Fuels' Dr. Amy Ruddock on aligning SAF with leasing interest 13

How delivery shortfall is keeping older twin-aisles flying 20

Arcadia eFuels: All eyes on EU Sustainable Transport Investment Plan (STIP) announcement to realize e-SAF offtakes 23

EU airlines' free carbon passes won't deliver green fuel goals 26

Reimagining flight: The Sustainable Aero Festival charts aviation's greener future 36

Can improving airline on-time performance (OTP) help reduce emissions? 41

From transition to delivery: Lahiru Ranasinghe on steering easyJet's decarbonization effort 43

impact Members' Call presentations 47

Introduction

Dr. Ulrike Ziegler

Chairwoman of the Board of impact on sustainable aviation e.V.

From ESG hype to a new normal: Where change is in your hands

Has ESG fatigue gotten the better of us? After two years of near-constant momentum across aviation's ESG and sustainability agenda, the industry now faces a defining moment: are we witnessing a retreat in the face of complexity — a quiet hope that e.g. Net Zero 2050 targets and e-SAF mandates will be delayed, reporting requirements softened, and the pressure eased? Does short-termism obscure the true cost of inaction beyond regulatory penalties and the risk of stranded assets whose impact could ultimately restrict access to capital? Or are we, instead, adjusting to a new reality — where sustainability is no longer a headline, but a core component of how we operate, finance, and grow?

What is clear is this: Sustainability is not a passing trend. It has become a long-term, strategic factor in every investment decision. Profitability remains paramount, but sustainability is firmly embedded in funding criteria. The transition is not a matter of if, but when — and with it comes opportunity for those ready to act.

As the aviation sector decarbonizes, the impact on how we do business will be profound. Regulatory shifts, SAF and carbon removal supply chains, new technologies, and infrastructure needs are now central to how the airline and lessor industry is financed— alongside traditional metrics like creditworthiness and asset quality. Add to this the evolving demands of non-financial reporting, and the pressure is felt across the board. Though initiatives like the EU Omnibus Package may streamline requirements and/or reduce the number of in-scope companies, reporting will remain essential for accessing capital. What matters now is relevance, transparency, and consistency. One of the building blocks is in the making – the "Practitioner's Guide – Milestone Concept[1]".

[1] To learn more, watch the 'ISTAT Learning Lab: Sustainable Finance Fundamentals: Driving Aviation Toward Net Zero with impact on sustainable aviation'.

This is where ***impact*** steps in — as a catalyst, a connector, and a 'do tank'. We are not here to observe the transition; we are here to build it. Our role is to bridge the gap between technology and finance, to help shape practical, credible standards, and to offer a trusted platform for knowledge-sharing and scaling real-world solutions. Reliable data, harmonized metrics, and transparent collaboration are no longer optional — they are essential for informed decision-making, robust risk assessment, and unlocking capital at scale.

The content of this edition of "***impact*** - Insights 2025" reflects just some of the many dynamics and decision points that will shape the future of aviation.

Finance remains the center of gravity in this transformation—it is essential to support the core business of airlines and lessors and the conditio sine qua non to financing aviation's decarbonization. At ***impact*** — a platform driven by leading financiers and aircraft lessors — we believe the entire ecosystem must move forward together: i.a. financiers, lessors, data providers, consultants, SAF and CDR developers.

ENGAGE WITH US - BECAUSE TOGETHER WE CAN MAKE THIS TRANSITION INVESTABLE, SCALABLE, AND REAL.

The sustainable aviation journey: Insights from the ISTAT/*impact* Sustainability Symposium

*From SAF scaling hurdles to cutting-edge engine design and sustainability-linked financing, this year's ISTAT Sustainability Symposium in cooperation with **impact**, sponsored by Avolon, spotlighted collaboration, innovation and long-term strategies as the aviation industry pushes toward Net Zero goals.*

The ISTAT Sustainability Symposium, held on 29 April at event sponsor Avolon's headquarters and in partnership with ***impact***, brought together aviation leaders, financial experts and sustainability advocates to examine the industry's progress — and roadblocks — toward decarbonization. Through a mix of keynote presentations, interactive sessions and forward-looking panels, attendees explored what it will truly take to transform aviation into a sustainable sector.

Boeing's Brian Moran on scaling SAF and innovation

The event opened with a keynote from Brian Moran, Chief Sustainability Officer at Boeing. Moran outlined Boeing's comprehensive sustainability strategy: focusing on fleet renewal, operational efficiency, renewable energy sources (like sustainable aviation fuel (SAF), hydrogen and electrification), advanced technologies and market-based measures. He introduced CASCADE, a data-driven forecast tool that models how these levers can reduce aviation's carbon footprint. Moran made a strong call for energy industry involvement in SAF scaleup, framing it not just as an environmental imperative but as an opportunity for energy resilience. He also emphasized the role lessors could play through innovative financing models, setting the

tone for a day that frequently returned to themes of collaboration and capital investment.

Honoring innovation: GA Telesis wins Sustainability Award

This year's ISTAT Sustainability Award went to GA Telesis for its ambitious sustainability strategy, which includes a goal of reaching 100% SAF usage by 2030 and alignment with 10 of the United Nations' Sustainable Development Goals. The award recognized the company's holistic approach to reducing aviation's environmental impact across operations and investments.

Political hurdles and policy misalignment

Moderated by Paul Sheridan, Aviation Finance Advisory Services Leader at PwC Ireland, the first panel unpacked the political and regulatory landscape, with insights from Donal Handley, Head of Government Affairs and Sustainability at AerCap, and Thomas Fowler, Director of Sustainability and Finance at Ryanair. Panelists expressed concern over the shift from the EU Green Deal to the Clean Industrial Deal and the unpredictable rollout of the Corporate Sustainability Reporting Directive (CSRD). Discussion centered on SAF mandates in Europe, particularly skepticism around the feasibility of achieving 6% blending and eSAF targets. The panel underscored the high cost of synthetic SAF and a lack of alignment among global regulators, which complicates the implementation of climate policies like CORSIA. The takeaway: safety must remain paramount, and Net Zero targets may require pragmatic reassessment.

The economics of sustainability

The second panel, led by Jim Morrison, Chief Risk Officer at Avolon, tackled macroeconomic dynamics and aircraft values with speakers Richard Evans, FRAeS, Senior Consultant at Cirium Ascend Consultancy; Ben Chapman, Director of Aircraft and Sustainability at ICF; and Stephen Rooney, Lead Economist at Tourism Economics. While aviation demand remains strong — driven largely by global wealth — supply chain delays are slowing fleet renewal, hindering sustainability goals. Panelists emphasized that newer aircraft and engine technologies could hedge against fuel price volatility, but economic uncertainty and fragmented regulation are stalling broader investment. A show-of-hands poll revealed a growing skepticism among attendees about the industry's ability to meet Net Zero targets, signaling a shift in sentiment from previous years.

Interactive session: Future technologies need financing

In a dynamic session on financing future aviation technologies, Marc Tembleque-Vilalta, Senior Vice President of Portfolio Strategy at Avolon, moderated a discussion featuring Sandrine Lacorre, Product Marketing General Manager at CFM, and Senior Adviser Hal Calamvokis. Lacorre highlighted CFM's RISE program, a next-gen engine design promising a 20% reduction in fuel use and full SAF compatibility. Key innovations like open-fan technology — with strong aerodynamic and noise reduction potential — were spotlighted, along with the importance of scaling green hydrogen. An audience poll reflected optimism about the introduction of new engine technologies before 2040, a hopeful contrast to the earlier skepticism.

Aircraft design, SAF feedstocks and the 2030 push

Moderated by Michael Halaby, Managing Director and Head of Aviation Advisory at MUFG Bank Ltd., the third panel brought together representatives from JetZero, Airbus and Vaeridion. JetZero's Chief Operating Officer, Dan da Silva, unveiled a blended wing-body aircraft design, focused on maximizing aerodynamic efficiency and dramatically reducing fuel burn. Ivor van Dartel, CEO and co-founder of Vaeridion, discussed Vaeridion's 100% electric aircraft for regional travel, pointing to 2030 as a critical milestone as battery efficiency improves. Julien Manhes, Head of SAF and CDR at Airbus, emphasized the manufacturer's threefold SAF strategy: defining sustainable feedstocks, stimulating demand and supply and addressing the nuances of offsetting. Across the board, panelists stressed that innovation in aircraft must be matched by progress in fuel sourcing and supply chain development.

Finance as a catalyst for sustainability

In the final panel, Ulrike Ziegler, President of ***impact***, led a discussion on sustainability-linked loans and leases, featuring finance and legal experts from Natixis CIB, SMBC, ACG and Norton Rose Fulbright. The panel, which included Jean Chedeville, Global Head of Aviation at Natixis CIB; Kaiori Creed, Senior Vice President of Airline Marketing for EMEA at SMBC Aviation Capital; Emma Giddings, Partner at Norton Rose Fulbright LLP; and Gordon Grant, Vice President and Head of ESG at ACG noted a drop in ESG-linked transactions in 2024 — blamed partly on regulatory complexity and geopolitical distractions — but said the market is diversifying. Key topics included avoiding greenwashing by using robust KPIs, the financing gap for SAF projects and the potential of linking KPIs directly to financial products. Panelists called for ambitious, transparent metrics, collaboration between lenders and operators, and a stronger ecosystem to support funding for innovation.

A call for unity and long-term thinking

Across all sessions, one theme resonated clearly: No one can decarbonize aviation alone. The path to Net Zero will require synchronized efforts among manufacturers, airlines, lessors, regulators, investors and energy producers. And while technological breakthroughs are within reach, the industry must overcome financing hurdles, policy fragmentation and supply chain delays to ensure sustainability is not just aspirational but achievable.

impact Webinars

Charting the course to Net Zero aviation: A collaborative journey

The aviation industry stands at a critical juncture in its decarbonization journey, as highlighted during the recent "Heading to Net Zero: Re-routing Aviation's Technology Transition?" webinar. Hosted by ISTAT and impact, the discussion brought together key stakeholders to map out the sector's path forward.

As the sector navigates this complex transition, adaptability will be key. The journey will require balancing immediate solutions like SAF with long-term bets on hydrogen, while continuously optimizing operations through innovations like contrail reduction. With coordinated action and sustained investment, the aviation industry can successfully reroute its course toward a sustainable future.

Moderated by Michael Halaby of MUFG, this webinar featuring insights from IAG's Jonathon Counsell, ICCT's Dan Rutherford, CFM International's Sandrine Lacorre, and ZeroAvia's Julian Renz, underscored both the challenges and opportunities in aviation's decarbonization story.

Watch the webinar here.

ISTAT Learning Lab: Sustainable Finance Fundamentals: Driving Aviation toward Net Zero

The ISTAT Learning Lab session, moderated by Nils Hallerstrom, explores sustainable finance strategies that support aviation's transition to Net Zero emissions with Jean Chedeville, Natixis, and Tom Conlon, University College Dublin. Key mechanisms and how these tools can mobilize private capital to fund decarbonization initiatives are outlined.

It is important to align financial instruments with environmental goals; also, a critical distinction between intensity-based metrics (e.g. emissions per passenger-kilometer), which can be misleading if absolute emissions rise, versus e.g. ***impact's*** Milestone Concept is recommended.

Sustainable finance is no silver bullet, it's a powerful tool to drive climate action when paired with transparency, accountability, and strategic implementation.

Watch the webinar here.

2024 commercial aviation emissions grow above 2019 levels

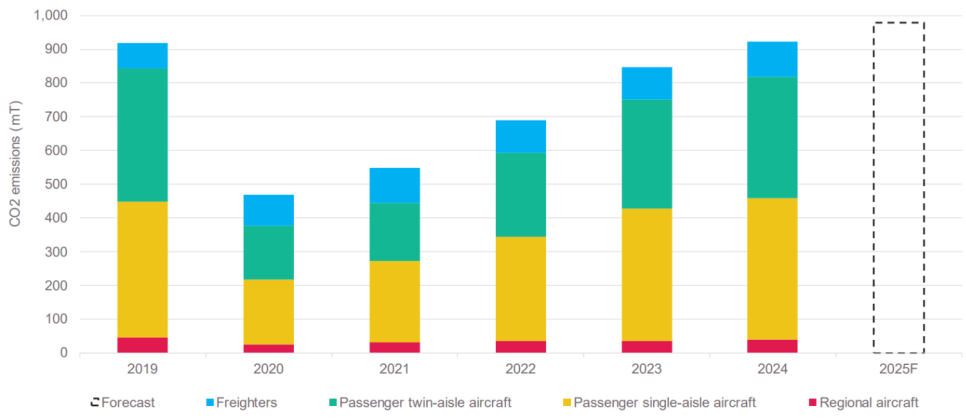
Richard Evans

Senior Consultant at Cirium Ascend Consultancy

The commercial aviation industry concluded its post-Covid recovery in 2024. Almost all markets, the exception being China's international sector and some Asian domestic markets, have exceeded 2019 traffic and capacity levels. IATA figures showed a 10.4% annual increase in revenue passenger kilometers (RPK) and an 11.3% increase in cargo ton kilometers in 2024. This means passenger traffic for 2024 was around 4% above 2019 levels, and freight traffic was 7% higher.

Cirium's tracked utilization data, which includes over 99% of all passenger and cargo flights, is used as the basis for estimated CO_2 emissions. Fuel-burn models are applied as part of our EmeraldSky emissions model. This is at the individual flight level for all scheduled and non-scheduled records with aircraft larger than 30-seater types. The annual data reveals that 2024 gross emissions were 1% higher than in the CORSIA baseline year of 2019. Within this figure, regional aircraft and twin-aisle passenger jets were still well below, with the increases in emissions driven by single-aisle passenger jets (up 4% versus 2019) and freighter aircraft. The latter saw a huge increase in usage during Covid, which has been sustained, largely by e-commerce, ever since. Freighters are often older-generation aircraft types, and their emissions have increased by 40% from 2019 to 2024.

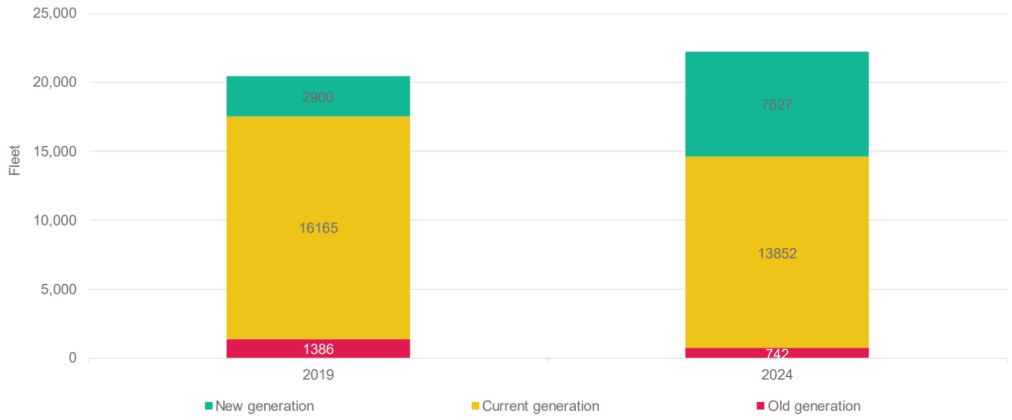
2024 commercial aviation CO_2 emissions were 1% above 2019 levels



Source: Cirium EmeraldSky emissions monitor, Cirium Fleet Forecast

In total, passenger aircraft emissions in 2024 were 3% lower in 2024 than in 2019, even with a 4% increase in RPKs over the period. This does show some success in improving efficiency, with CO_2/RPK down around 7% on this basis. Given that passenger load factor in 2024 was very close to 2019, this efficiency gain is down to changes in the fleet mix, with many older-generation types replaced by new aircraft such as the Airbus A320neo family, A350, Boeing 737 Max, or 787. Even with the well-known supply constraints at Airbus and Boeing, the fleet mix at the end of 2024 shows a much higher penetration of latest-generation types. These now make up 34% of the passenger fleet, up from 14% at the end of 2019. The typical fuel, and hence CO_2, benefit of replacing an older type (e.g. A320ceo, 737-800, A330-300) with a new-generation aircraft (A320neo, 737-8 Max, A350-900) is 10-20%.

Latest generation types now 34% of the passenger fleet, up from 14% in 2019



Source: Cirium Fleets Analyzer - airline passenger usage, single-aisle and twin-aisle aircraft

Looking ahead to 2025, we expect passenger traffic to grow by 7-8% over 2024, with gross emissions increasing around 6%. Unfortunately, the penetration of sustainable aviation fuel will be too small to make a significant dent on this increase, with IATA estimating around 0.3% SAF usage in 2024, perhaps growing to 0.5-1.0% this year. Thus, the divergence between actual net CO_2 emissions and Net Zero pathways will widen further.

Emissions by airline domicile region very much reflect the traffic growth trends since 2019. North America and Europe are the two largest emitters, although European airline emissions are still 1.6% below 2019 levels. CO_2 emissions have grown the most over the past five years in Africa and India, driven by strong economic growth and a rapid post-Covid traffic recovery. The rest of Asia-Pacific has seen emissions cut since 2019, as a result of the slow recovery in traffic to/from China (by non-Chinese airlines) and capacity cuts in Indonesia.

Operator region	2024 CO_2 emissions (million tons)	Change versus 2019
North America	227	+4.0%
Europe	229	-1.6%
Asia-Pacific (excl. India/China)	163	-8.0%
India	22	+21.2%
China	118	+5.1%
Middle East	93	+3.0%
Africa	23	+17.6%
South & Central America	44	+7.0%

This analysis indicates that the aviation industry has started to grow both gross and net emissions above the 2019 baseline once again. Strong demand underpins this, with the move to more efficient aircraft and take-up of SAF being insufficient to offset growth. It is likely 2025 will see a further significant increase in aviation CO_2 emissions. How the airline industry and governments react to these increases is uncertain, and likely to vary between regions and individual states. Aviation is much more difficult, and expensive, to decarbonize than other sectors, and this reality will become more obvious than ever in 2025.

More info on Cirium's EmeraldSky emissions monitor here.

Willis Sustainable Fuels' Dr. Amy Ruddock on aligning SAF with leasing interest

Dr. Amy Ruddock

Senior Vice President of Sustainable Aviation and Corporate Development at Willis Lease Finance Corporation

Written by Eduardo Mariz, Sustainability Lead and Senior Analyst at Ishka

*With questions by Ulrike Ziegler (Chairwoman of the Board of **impact**) and Eduardo Mariz*

The question is being asked with increasing frequency: How can some of the best-capitalized companies in aviation drive the scale-up of advanced sustainable aviation fuel (SAF) production — an emerging industry still in its initial stages? Willis Lease Finance Corporation (WLFC), a leading global engine leasing and aviation services provider, is among the few stepping up to lead by example. Through its subsidiary, Willis Sustainable Fuels, an aviation decarbonization project developer established in 2022, the company is developing a SAF production facility near Teesside International Airport in northeast England.

impact speaks with Amy Ruddock, SVP of Sustainable Aviation and Corporate Development, to explore what led WLFC to invest in SAF, how SAF aligns with its business strategy, and the role the leasing sector can play in accelerating SAF production.

Four reasons: the underpinnings of WLFC's SAF involvement

For WLFC, the opportunity to become involved in SAF emerged at Teesside International Airport, where in addition to having an MRO facility the company also provides airport FBO and cargo handling services. Teesside is also where the UK's first SAF handling waterside terminal is set to be located, and the site of the country's first decarbonized industrial cluster. "This is our continued investment in the Teesside region," explains Ruddock, citing WLFC's ongoing presence in the area as one of four key reasons.

Opportunity favors those prepared to seize it, and Ruddock credits the company's move into a new sector to its entrepreneurial spirit. "WLFC has been a cornerstone of the aviation industry for four decades. Our deep-rooted presence in this field means that our future is directly tied to the industry's success and sustainable growth. So, I think, motivation number one is clear: this is our industry, and our ability to thrive depends on it."

Ruddock also views the upcoming Teesside SAF facility as being well-positioned within the right regulatory environment. She describes the UK's SAF policy, both existing and under development, as "really important," particularly the UK mandate's cap on first-generation HEFA SAF derived from waste bio feedstocks, and its focus on carbon intensity reduction. "The UK mandate also has a buyout price in it, which is helpful. It provides a price signal, which is effectively a price ceiling. It doesn't provide a price floor, which can be a challenge when you are going out for debt financing, and you have a market that hasn't been tried and tested at scale, and I think that's where the Revenue Certainty Mechanism comes in."

"It's a high-growth industry with clear mandated market demand and a short supply. There is just that opportunity to have a role within a multi-billion-dollar business that's growing," she explains, adding that WLFC has the right "nimble" size and corporate culture to adapt and thrive in a fast-changing sector. Lastly, she argues, WLFC can "bring something to the table" that other SAF developers may not. "We bring really deep aviation knowledge, an understanding of what customers want, and the ability to go and speak to airline customers."

What is WLFC building?

Willis Sustainable Fuels' first project in Teesside will be a 14,000 tons-per-annum SAF production facility projected to start operations at the end of 2027 or start of 2028. It will be a biomethane-to-liquid (BtL) refinery using a novel technology called Carbonshift FlexFeed. Ruddock describes this technology as "power-to-liquid ready." "Fundamentally, it's a process that is designed to produce power-to-liquid fuels, the third generation of fuels, but in the meantime, it can flexibly use bio-methane or green hydrogen as its input. Doing this, allows us to adapt with market demands." Unlike other technologies, the plant will produce 100% SAF and not synthetic crude.

Helping derisk this novel approach is "proven equipment from well-known suppliers," which Ruddock says is integrated in new ways. "That means that

we are de-risking delivery versus having lower technology readiness equipment."

The role of leasing in the SAF scale-up

As the aviation industry grapples with the challenge of decarbonization, there are growing pressures for lessors to expand their role beyond leasing. For Ruddock, lessors continuing to play their role in the value chain by financing the most efficient aircraft and engines is key, but she also believes leasing firms should not ignore other decarbonization levers, including SAF. "As the leasing community, we do have the responsibility to find ways to respond, to support SAF and carbon dioxide removal initiatives. Any investment in lowering carbon is a commercial investment too—it's an investment in the future of the industry."

Ruddock believes that lessors have a range of options for engaging with SAF, including direct investment or project development, similar to WLFC's approach, as well as the potential integration of SAF certificates into leasing contracts. The latter could help SAF project developers overcome the challenge of securing long-term, bankable offtake agreements, which are currently lacking. "For banks to provide loans, the offtaker needs to be investment-grade—banks need confidence that the party can uphold their contractual obligations. However, in the aviation industry, there are few investment-grade potential offtakers."

Playing the role of an offtaker could also create a commercial differentiator for airline customers in regions "disadvantaged in SAF access today." "It's definitely a short-to-medium term opportunity," Ruddock believes, before the SAF market reaches a level of liquidity that allows airlines to return to shorter-term supply contracts.

Watch the video of the interview with Amy Ruddock here.

Quantifying the cost of compliance: A sensitivity analysis of SAF mandates and penalties in the EU aviation market (2025–2035)

Dana Shoukroun

Director at Invest Through Flying

Introduction

The decarbonization of aviation is becoming central to European and global climate strategies. With aviation contributing around 2.5% of global CO_2 emissions and its share expected to grow, the EU has introduced the ReFuelEU Aviation Regulation, a core pillar of the Fit for 55 package aimed at reducing greenhouse gas emissions by 2030. ReFuelEU Aviation mandates gradual sustainable aviation fuel (SAF) blending: 2% by 2025, 6% by 2030, and 20% by 2035 with further increases planned through to 2050, along with specific sub-mandates for synthetic e-SAF. Penalties for non-compliance are set at twice the price difference between SAF (or e-SAF) and fossil jet fuel.

However, SAF production remains limited and costly, particularly outside the mature HEFA pathway. As airlines also face rising costs under the EU Emissions Trading System (ETS), which prices CO_2 emissions from fossil jet fuel, understanding the interaction between mandates, carbon pricing, and fuel supply is essential.

This article presents a quantitative sensitivity analysis exploring four SAF compliance scenarios under low, mid, and high price trajectories for SAF and EU ETS. It quantifies total fuel costs to airlines and identifies strategic insights for investment and risk management.

Methodology

The model assesses fuel costs to airlines with EU/EEA flight departures covered by the EU ETS from 2025 to 2035 across four SAF supply scenarios:

- Scenario 1: Zero Compliance (no SAF or e-SAF use, full penalties incurred)
- Scenario 2: Realistic Compliance (based on committed SAF refinery projects)
- Scenario 3: Accelerated Compliance (doubling SAF production every 5 years)
- Scenario 4: Full Compliance (full SAF and e-SAF mandate coverage)

Each scenario is tested across three market cases:

- Low: lower ETS (€100/tCO_2 in 2035), lower SAF costs
- Mid: ETS at €150/tCO_2 in 2035, moderate SAF costs
- High: ETS at €200/tCO_2 in 2035, high SAF costs

Jet A prices rise at 2% annually, from €734/t in 2025 to €895/t in 2035. SAF costs vary by pathway and scenario, with average SAF prices declining by 30% by 2030 and 45% by 2035. Penalties are calculated as twice the price differential between Jet A and SAF/e-SAF. ETS charges are computed using ICAO CORSIA emissions values.

The model applies the SAF and e-SAF mandates to projected fuel demand (rising from 46Mt in 2025 to 59Mt in 2035), allocates available SAF supply to meet mandates, and calculates shortfalls and penalties. Output metrics include fuel premiums and effective fuel cost per tonne.

Results

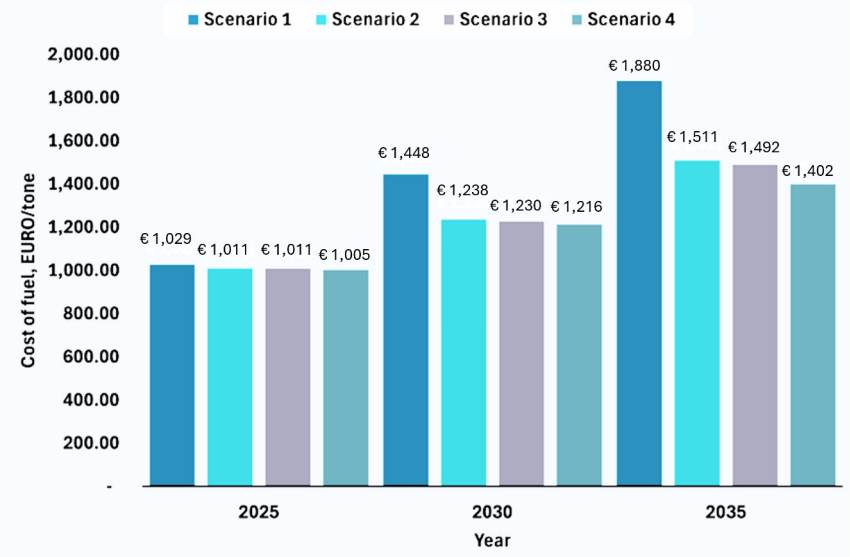
In the mid-range market case, Scenario 1 illustrates the highest cost path. By 2035, with no SAF compliance, penalties and ETS drive the total fuel cost to €1,879/t, covering the cost of Jet A, SAF blend, EU ETS compliance and penalties from non-compliance ReFuelEU mandates. The ETS alone adds €474/t of fuel, accounting for more than half the premium. This scenario starkly highlights the economic unsustainability of inaction.

Scenario 2, reflecting only partial SAF compliance from FID-level projects, shows modest cost reductions. By 2035, the fuel cost reaches €1,511/t, still heavily influenced by the ETS, while penalties are only slightly reduced due to limited SAF and e-SAF availability. The reduced SAF blending partially offsets penalties, but the overall impact remains minimal without addressing the e-SAF shortfall.

Scenario 3, with accelerated production, offers more noticeable cost benefits. Doubling SAF supply every five years reduces shortfalls more significantly. The 2035 fuel cost drops to €1,492/t, with blending costs slightly increasing but penalties shrinking further. Still, the ETS remains the primary cost driver, reinforcing the need to simultaneously scale e-SAF supply to fully neutralize regulatory charges.

Scenario 4, representing full SAF and e-SAF compliance, delivers the lowest cost outcomes. By 2035, fuel costs stand at €1,402/t. Here, penalties are eliminated entirely, and the reduced emissions exposure from SAF use curtails ETS costs substantially. SAF becomes a proactive hedge against policy-induced price volatility, not merely a compliance mechanism.

Cost of fuel per ton for Scenarios 1-4 using mid-range market case

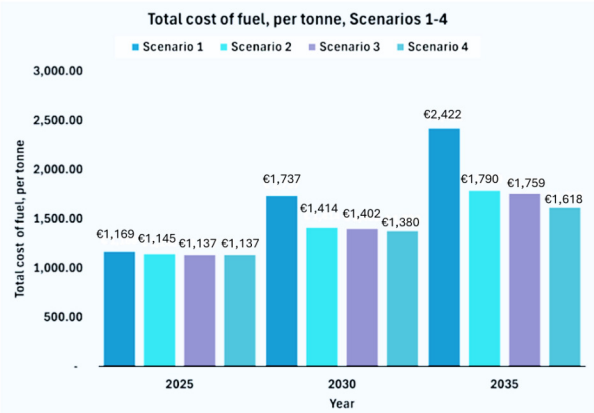


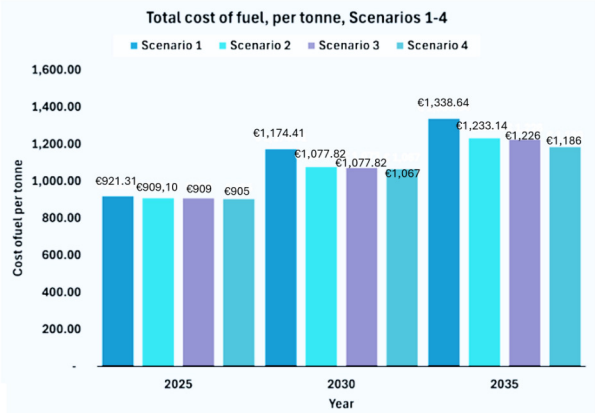
Under the low-range market case, where the cost of SAF and EU ETS are lower than the medium-range market case, the same structural trends persist. Scenario 1, despite lower carbon pricing and SAF costs, still leads to the highest 2035 fuel cost at €1,338/t. The ETS continues to dominate total premiums. Scenario 2 reduces this to €1,233/t, while Scenario 3 performs marginally better at €1,226/t. Scenario 4 again delivers the lowest cost at €1,185/t, demonstrating that full compliance is economically advantageous even in a low-policy-pressure world.

The high-range market case as shown in Figure 2, where the cost of SAF and EU ETS are much higher, underscores the cost of delayed SAF action. In Scenario 1, total fuel cost balloons to €2,422/t by 2035, driven by a €632 ETS burden and nearly €900 in penalties. Scenario 2 improves the situation slightly, reducing costs to €1,789/t, while Scenario 3 further lowers it to €1,799/t.

Scenario 4 provides the most cost-effective result at €1,618/t, a full €804/t less than Scenario 1.

Cost of fuel for Scenarios 1-4 using low-range market case (left) and high-range market case (right)





Conclusion

Across all scenarios and policy environments, the dominant economic risk is ETS exposure, not SAF cost. ETS charges consistently account for over half of added fuel costs under non-compliance. Even under optimistic assumptions, delaying SAF investment leads to higher long-term costs.

Full compliance with SAF mandates, especially when coupled with cost learning from scaled production, emerges as the only pathway to cost control. SAF is not a luxury; it is a financial hedge against the rising cost of carbon. Investing in SAF supply chains, scaling technology, and securing offtake agreements now will position airlines and fuel suppliers to thrive in a carbon-constrained future.

How delivery shortfall is keeping older twin-aisles flying

Max Kingsley-Jones

Head of Advisory at Cirium Ascend Consultancy

This article examines the impact of twin-aisle delivery delays on airline plans to replace their prior-generation fleets

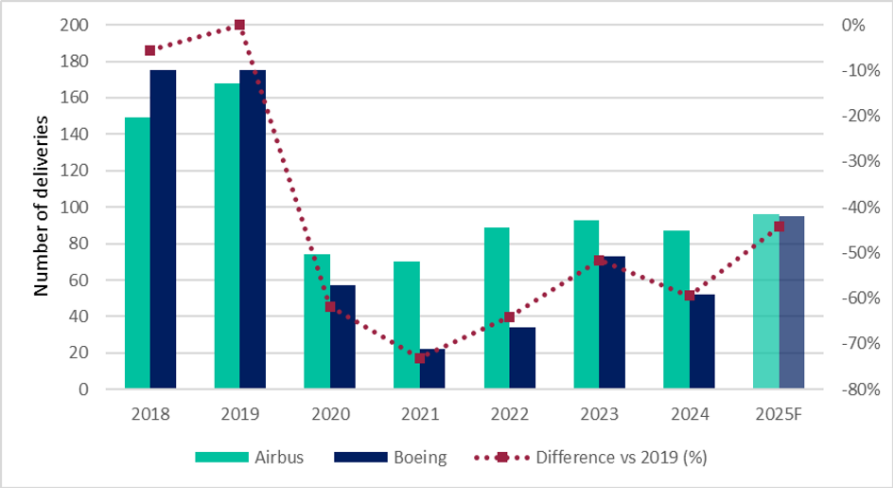
When one peers skywards on a clear summer's day, it's illuminating to spot how the condensation trails from twin-engined aircraft are often interspersed with those from four-engined jets, (or "quads"). While some of these trails are usually from Boeing 747 freighters, there are often still a few passenger versions of Boeing's "sky queen" flying over. There are also, of course, around 170 Airbus A380s back in service, after the fleet showed a much stronger recovery than many operators indicated it would during the depths of the pandemic. There is also still a small fleet of the other twin-aisle quad in operation – the A340.

And mixing among those twin-engined contrails are older-generation aircraft types like the Airbus A330ceo, and Boeing 767 and 777, that burn more fuel per RPK than is ideal, from both environmental and operating-cost perspectives.

The fact is that several years into the airline industry's post-Covid recovery, airlines are having to retain their older twin-aisle twinjets and quads in service for longer than planned due to sustained delays to deliveries of new replacements. This factor has resulted in more older widebody twinjets being reactivated post-Covid and retained in the passenger role, rather than transitioning to the freight sector or being parted out. Older quads like the 747-400 and A340 were unexpectedly returned to service post Covid, while the A380 appears to have been given a lengthy stay of execution.

At the start of the pandemic, Boeing's new-generation 777-9 was expected to enter service by the end of 2022 (this was already delayed from the original target of 2020). That revised schedule was subsequently subject to further extensive delays amid program and certification issues. Boeing now expects service entry in mid-2026 - much to the frustration of early customers.

Annual passenger twin-aisle deliveries



Source: Cirium Fleets Analyzer (2019 = peak in pax twin-aisle deliveries)

Since twin-aisle annual deliveries peaked in 2019, annual shipments have averaged 60% lower through 2020-24 and are forecast to remain over 40% down this year. Much of the deficit has resulted from a very significant reduction in 787 deliveries (72% lower than forecast). Notable also was the absence of the 777-9 to succeed the 777-300ER, while lower Airbus volumes are also a major factor. Production of the A330 and A350 has not been sufficiently increased to match pre-Covid volumes or production expanded to replace the void left by the A380's demise.

Among the 777-9 customers affected by the shortfall in new-generation twin-aisle deliveries – and which revived and/or retained more older widebodies post-Covid than intended – are Cathay Pacific, British Airways, Qatar Airways, Etihad Airways and Emirates. Lufthansa, which is designated as 777-9 launch operator, is operating a fleet of some 59 four-engined twin-aisles this summer: 16 A340-300s and eight -600s, eight A380s, eight 747-400s, and all 19 of its 747-8Is.

Another 777-9 customer, Korean Air, recently disclosed it was postponing the planned retirements of its A380s and 747-8Is amid the ongoing delays. The airline had initially indicated that it would begin removing its four A380s in 2025, but that plan is now indefinitely postponed.

To try to quantify the effect of the slow production-rate increases post-Covid, along with the continued absence of the 777-9, a comparison of the 2019 Cirium Fleet Forecast (CFF) with the latest edition (2024) sheds some light. It shows, for example, that in 2019, Cirium was projecting that almost 200 777-9s

would have been delivered worldwide by the end of 2024. But as stated above, the first shipment is still another year away at least.

The year-end fleet of passenger twin-aisles at the end of 2024 was 30% lower than Cirium projected in its 2019 forecast. The shortfall in the annual in-service fleet projection between our 2019 and 2024 CFFs remains at 25-30% through to 2030. However, within those numbers there is churn between the fleets of the new-generation and prior-generation twin-aisles.

When comparing the two forecasts, it becomes evident that the limited delivery volume of new-generation twin-aisles since 2020 has prompted more prior-generation twin-aisles to be retained in passenger service.

In 2024, the fleet of prior-generation twin-aisles was only 17% lower than projected in the 2019 forecast, while the new-generation inventory was 39% lower. Although the two categories' in-service fleet divergence between the 2024 and 2019 forecasts moderates through the 2020s, they remain significantly different even by 2030, ending the period 10% and 28% lower than 2019's forecast, respectively.

The need for widebody lift has prompted many more quads to return to or remain in service after Covid than even the airlines originally expected, but the fleet share (of all twin-aisles) between the two forecasts is very similar. The share was forecast in 2019 to be 7% in 2024 (on different overall volumes) but was in fact a point higher at 8%.

However, the expected rundown of the four-engined fleets is effectively identical between the two forecasts, with the fleet share expected to progressively reduce to 4% by 2030.

While overall shares are similar, what has changed of course is the overall volume of four-engined widebodies in service, compared with our 2019 forecast. The 2024 year-end inventory was forecast in 2019 to be 375 aircraft, but the actual fleet was around 30% lower, at 268.

The likely rate at which the in-service fleet of prior-generation twin-aisles will reduce – in particular the four-engined ones – remains uncertain. Much depends on the pace of ramp-up of the A350 and 787 programs and when the U.S. Federal Aviation Administration finally certificates the 777-9 – and of course any downward deviations in the demand for long-haul travel.

Arcadia eFuels: All eyes on EU Sustainable Transport Investment Plan (STIP) announcement to realize e-SAF offtakes

Amy Hebert

CEO at Arcadia efuels

Written by Eduardo Mariz, Sustainability Lead and Senior Analyst at Ishka

*With questions by **impact's** Reporting Workstream*

Highly desirable but tough to contract, that's the conundrum faced by e-SAF project developers in Europe today. Despite their efforts in bringing to reality the most promising drop-in fuels to decarbonize aviation, e-SAF project developers are struggling to secure bankable long-term supply deals to bring planned facilities to investment closure.

One of those firms is Copenhagen-based Arcadia eFuels, which has played a pivotal role in uniting multiple e-SAF stakeholders under Project SkyPower (of which ***impact*** is also a member). Launched in mid-2024, Project SkyPower has the ambitious goal of supporting the first large-scale e-SAF plant to reach Final Investment Decision (FID) by the end of 2025 to be operational by 2030.

With that deadline fast approaching, ***impact*** caught up with Arcadia eFuels' CEO Amy Hebert to understand the progress so far, and how Arcadia sees the e-SAF scale-up playing out. "I think it's feasible still. We still have six months left in the year and it all comes down to offtake agreements. If we had a long-term offtake agreement in hand, then we could be at FID pretty immediately after that," Hebert explains.

A 'nice' but insufficient e-SAF voluntary market

A paradox for e-SAF firms is that the voluntary market for SAF, much of it driven by short-term fuel purchases, can become an enabler for e-SAF projects, but not in the near-term. "Once e-SAF plans are up and running, there's quite a few people that are interested in shorter-term agreements. So, for example, private airlines, private jets, we also see various freight carriers wanting to

have carbon neutral fuel so that they can then lower the Scope 3 emissions for their customers," comments Hebert.

The catch is that none of those sources of demand have the risk appetite for long-term agreements. "There is quite a nice voluntary market, but that, again, is not going to be the baseload for financing some of these large e-SAF projects."

STIP: A turning point

To create that baseload, in the six months to the end of the year there is one eagerly awaited moment: the European Commission's planned launch of its Sustainable Transport Investment Plan (STIP) in the third quarter of this year. The STIP, a policy package underpinning the EU Clean Industrial Deal launched last February, will outline short-term measures to support specific renewable and low-carbon fuels for aviation and waterborne transport.

"If those drivers look really positive and governments can move fast, which is a big if, because of the way the EU is structured, there still is a glimmer of hope that e-SAF bankable offtakes can happen," Hebert reflects. The Commission has promised to introduce an e-SAF price support mechanism under the STIP, and Project SkyPower through its policy workstream has been actively influencing its development.

The work of Project SkyPower does not stop there. Other workstreams are advancing project risk mitigation by engaging the financial sector (ECAs, public investment banks, EPC contractors, insurance companies), and putting forward other ideas such as using ETS revenues to bridge the price gap between fossil fuel and e-SAF. Hebert finds it "very disturbing" that a large portion of Europe's aviation-derived ETS revenues today and passenger are "not going to aviation 100%."

EU needs further support and incentives

Another element that could support e-SAF project developers is access to early-stage funding, and incentives for green hydrogen – a cornerstone of e-fuel production.

Hebert estimates that an e-SAF project developer requires approximately €60 million to fund development through to FID, but funding availability remains uneven. For instance, while Arcadia has secured funding in the U.S. and UK, it has not yet received funding in Denmark – the location of its first project. That

project, around 100km south of Copenhagen, aims to leverage biomethane-derived CO_2 and benefit from Denmark's rapidly decarbonizing grid to power hydrogen electrolyzers. The project obtained its operating permit earlier this year after a wait of more than three years.

As for hydrogen incentives, Hebert regrets that while the U.S. and UK have government per-kilogram incentives* for green hydrogen of up to $3 and £9.49 respectively, the EU's Hydrogen Bank auction last year cleared subsidies as low as €0.37. "It's just not even in the same ballpark."

Reassured by mandates

Despite its policy shortfalls, the EU has been sending the right signals around its commitment to e-SAF. Criticism by several airlines of ReFuelEU Aviation (i.e. the EU SAF mandate) became fierce earlier in the year, as teething issues with its implementation fuelled frustration at the prospect of operational costs ballooning from 2030 on account of non-compliance penalties caused by potentially unfulfilled e-SAF sub-mandates.

Since then, the European Commission has held its ground, refusing to back down on the mandated targets despite pressure. "We heard clearly from DG MOVE, the Commission's transport directorate, and others that the mandates are not going away. I'm sure that the fuel distributors would like to see that because they're the ones having to pay the penalty, and they're not the ones building e-SAF projects," comments Hebert.

"But again, if we look at the big picture and what's right for climate change and in order to reach full EU goals, e-SAF must be a key part of the solution."

* The Clean Hydrogen Production Tax Credit (45V) can go up to $3.00 per kg, the UK Hydrogen Allocation Rounds (HARs) can reach £9.49 per kg.

EU airlines' free carbon passes won't deliver green fuel goals

Emma Coker, Lead European Carbon Market Research

Huan Chang, Associate EU Environmental Markets and Carbon

Rosy Finlayson, Analyst EU Environmental Markets and Carbon

Daisy Robinson, Specialist Renewable Fuels at BloombergNEF

The European Union is mobilizing revenue from its carbon market to subsidize the increased use of low-carbon aviation fuels, but it's far from enough.

Some 20 million emission permits under the EU Emissions Trading System – representing 20 million metric tons of CO_2 – will be distributed for free to aircraft operators from 2024 to 2030 if their aviation fuel is blended with eligible lower-carbon alternatives. That aid, though, is a far cry from what is needed to achieve the bloc's ambitions for the increased adoption of sustainable aviation fuel (SAF).

SAF and other less emissions-intensive options consumed by aircraft are significantly more costly than fossil jet fuel. In 2024, an average carbon price of €363 per metric ton of CO_2 equivalent would be needed to incentivize the use of aviation biofuel, six times the €67/t CO_2e average EU carbon prices in that year.

Despite this, policymakers have mandated the minimum blend of SAF in jet fuel at 6% by 2030, up from 2% in 2025. This will bring an additional cost of up to €12 billion between 2024 and 2030 to airlines – of which less than half could be met by the free carbon passes.

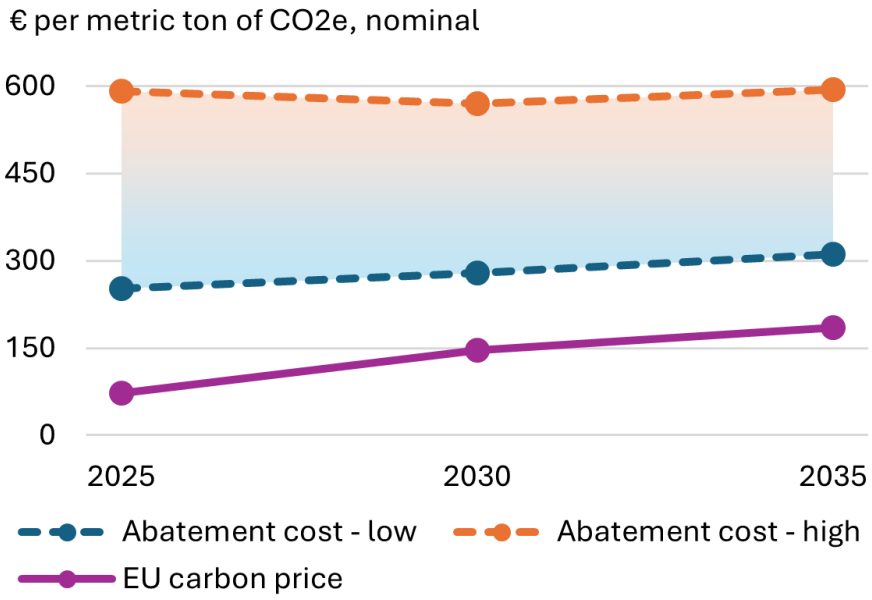
EU carbon price is not high enough to incentivize use of greener jet fuel

While emissions from fossil jet fuel fall within the EU's carbon market, the current carbon price is far too low to incentivize any shift toward greener aviation fuel.

According to the latest numbers published by the European Commission, the levelized cost of fossil-based jet fuel – kerosene – is around €2.8 per gallon in the EU, whereas the cost of mainstream SAF – biogenic fuel produced via hydroprocessing – averages €6.3 per gallon.

As such, BloombergNEF expects that the abatement cost (the carbon price needed to incentivize a shift to greener technologies) for the hydroprocessed biogenic SAF ranges between €252-591/t CO_2e in 2025 and will remain within a range of €311-594/t CO_2e even by 2035 (nominal terms). That's almost double the forecast European average carbon price of €185/t CO_2e in 2035.

Carbon abatement cost of hydro-processed biogenic SAF in Europe and forecast European carbon price



Source: BloombergNEF's Renewable Fuel Levelized Costs: Hydroprocessing (web | terminal).
Note: SAF refers to sustainable aviation fuel. The Netherlands represents jet fuel cost in Europe. Jet kerosene emission factor of 3.16 tCO_2/t fuel applied. The main variants in the two cost scenarios are the blend of renewable hydrogen used.

The high cost of SAF is largely driven by the feedstock, for example waste oil, fat or vegetable oil, which accounts for up to 80% of the levelized cost. Feedstock will remain the main contributor to SAF's high cost until 2050.

Bloc's SAF target needs up to €11 billion

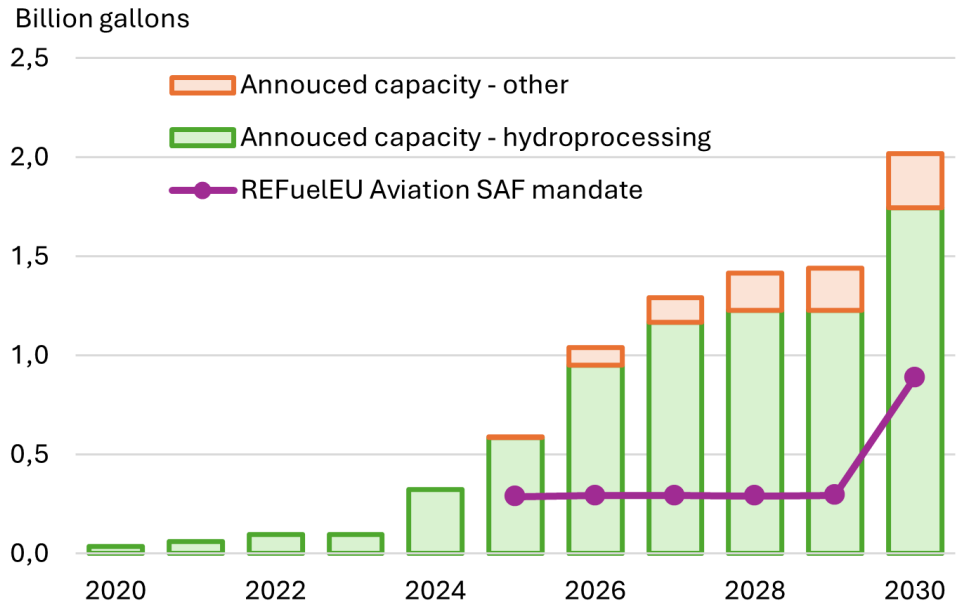
Europe has set one of the strongest demand signals for sustainable fuel in the world. Starting in 2025, the European Commission's ReFuelEU Aviation regulation has mandated a minimum SAF blend of 6% at all EU airports by 2030, and 70% by 2050.

Based on this target, 889 million gallons of SAF will be required by 2030. Project developers seem to be more ambitious – they have announced 2 billion gallons of SAF supply by 2030. For more, see Global Renewable Fuel Projects Tracker.

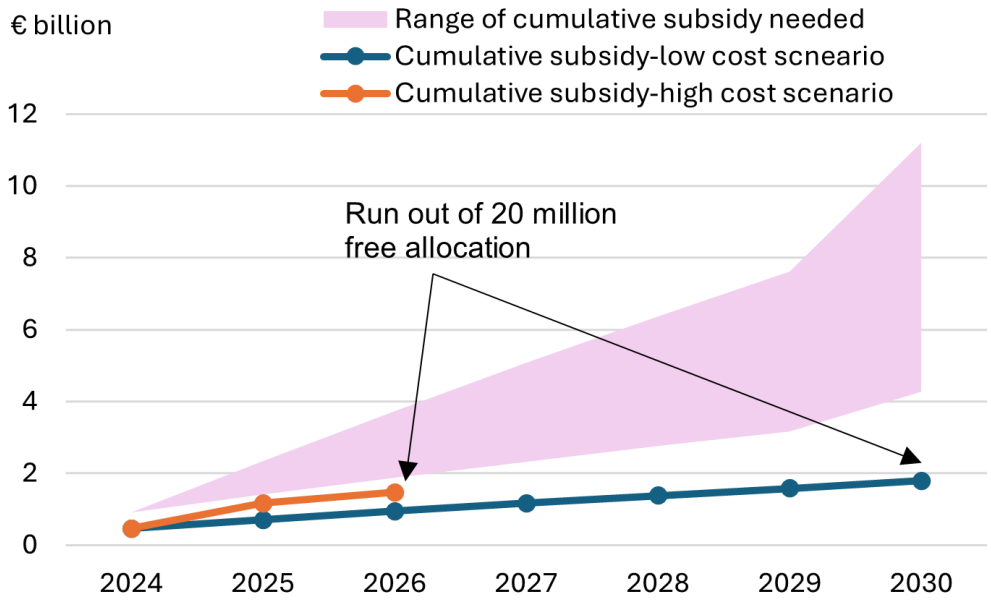
Biogenic SAF will account for most capacity due to its availability as well as relatively lower costs, according to both BNEF and a recent study from the European Union Aviation Safety Agency (EASA).

Achieving these targets would translate to around 8.5 million metric tons of CO_2 annual emissions abatement in the bloc's aviation sector by 2030. The current EU carbon price alone is too low to incentivize such a transition. It needs an additional €4-11 billion subsidy cumulatively between 2024 and 2030.

ReFuelEU Aviation SAF mandate and announced SAF projects in the EU



EU carbon market subsidy on SAF compared to the investment needed, 2024-2030



Source: BloombergNEF's 2024 Sustainable Aviation Fuel Outlook: Getting Airborne and Global Renewable Fuel Projects Tracker. Note: SAF refers to sustainable aviation fuel. Subsidy for 2024 calculated based on European Commission's publication on SAF and kerosene costs. Subsidy estimation from 2025 onwards based on BNEF's estimation of hydroprocessing biofuel costs.

EU handout not enough to reach SAF targets

The bloc has given the go-ahead for the use of some revenues generated from its carbon market to close the cost gap needed for SAF, despite a pledge to cut the sector's free allowances by 2026.

The Commission approved an exception of up to 20 million emission allowances (equal to 20Mt CO_2e) that could be allocated for free by 2030, to subsidize the price differential between fossil-based jet fuel and eligible aviation fuels from 2024. This covers up to 95% of the price difference for synthetic fuels, 70% for advanced biofuels, renewable and low-carbon hydrogen, as well as 50% of other non-fossil originated fuels.

Price difference = price of eligible aviation fuel – (price of fossil kerosene + EU ETS price + difference in taxation)

Additional details on the rules governing the calculation of the price difference between eligible aviation fuels and fossil kerosene were adopted on February 6, 2025, and can be found here.

According to BNEF's carbon price forecast, the 20 million free allocations could help provide around €1.5-1.8 billion subsidy in total, but this will only cover 42% of investment needed for biogenic SAF under the low-cost scenario, or 13% under high-cost scenario.

Prices of emissions allowances are not static, so the total value of subsidy is hard to tie down. BNEF expects allowance prices to double by 2030, to €147/t CO_2e, compared to the average of €73/t forecasted for 2025. As such, it is possible for aircraft operators to sell off obtained free allocations this decade to capture a higher value of the subsidy.

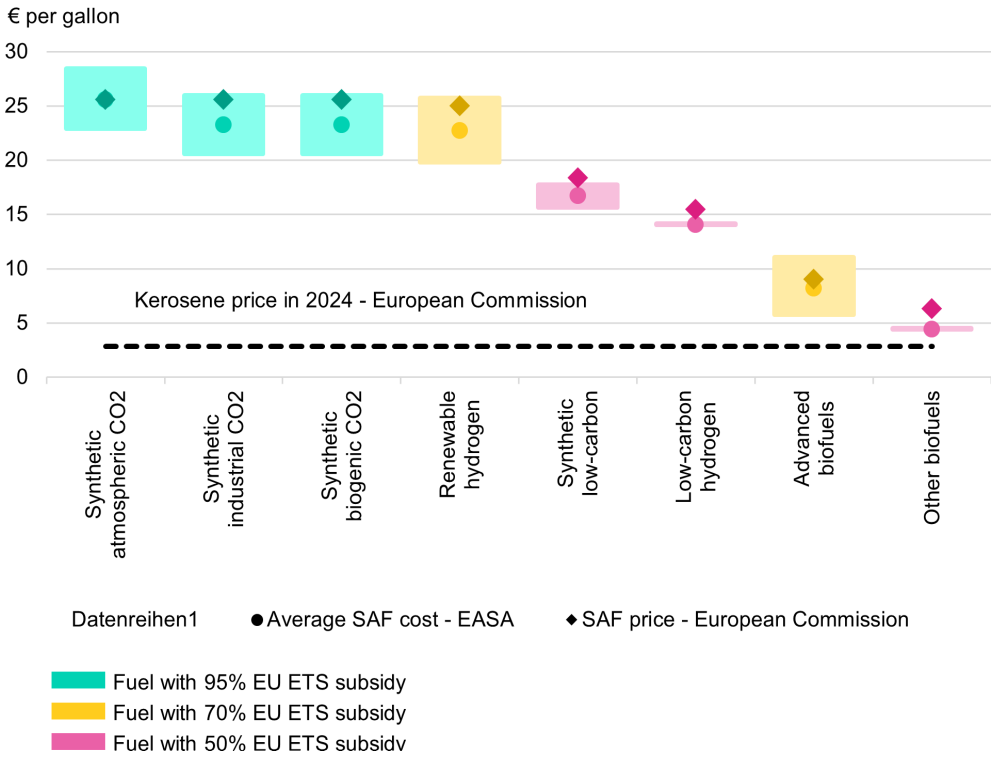
Biogenic sustainable aviation fuel to remain mainstream this decade

This subsidy is likely to encourage the uptake of biogenic over other eligible aviation fuels which also qualify under the EU's ReFuelEU Aviation regulation.

Compared to alternatives such as synthetic fuels or hydrogen-based fuels, biofuels are estimated to be the lowest cost, and the only technology available today, according to the EASA report.

Due to the high costs of synthetic aviation fuels, EASA expects them to have almost no capacity in thr EU in 2030, which puts the 1.2% sub-mandate for synthetic aviation fuels in 2030 in jeopardy. According to BNEF's Renewable Fuels Project Tracker, planned e-fuel projects in the EU could just about meet the mandate in 2030, however these projects remain at a very early stage. Given construction timelines of 3-4 years, the next year will be critical for these projects to reach FID in order to be ready in time for the 2030 mandate.

Cost range and prices of alternative aviation fuels eligible for EU ETS subsidy in 2040



Source: European Commission and EASA's 2024 Aviation Fuels Reference Prices for ReFuelEU Aviation.

Airport sustainable finance begins embracing aircraft emission KPIs

Eduardo Mariz

Sustainability Lead and Senior Analyst at Ishka

Rob Neale

Chief Product Officer at PACE

Sustainability-linked financing has grown increasingly popular among airports over the past three years, accounting for around two-thirds of all airport sustainable financings between 2022 and 2024. Most of those sustainability-linked transactions tie a portion of their fees or margins to sustainability performance targets (SPTs) based on an airport's direct emissions or other controllable metrics. Increasingly however, several airports are incorporating indirect emissions targets (Scope 3 emissions) to sustainability-linked transactions, including aircraft emissions.

What's in an airport's Scope 3?

For an airport, Scope 3 emissions include, primarily, those from passenger ground transportation to the airport, which can be mitigated by encouraging the use of public transit or electric vehicles. However, by far the largest source of Scope 3 emissions comes from aircraft flights. Those aircraft emissions can be measured in two ways:

- Landing and Take-Off (LTO) GHG emissions metrics are derived from the ICAO Doc 9889 definition of an LTO cycle for aircraft engine emissions certification purposes. The LTO cycle consists of four modal phases chosen to represent approach, taxi/idle, take-off and climb. It assumes that operation at take-off power abruptly changes to climb power at the end of the take-off roll and that this is maintained unchanged up to a specific altitude which is generally considered to be 3000ft.

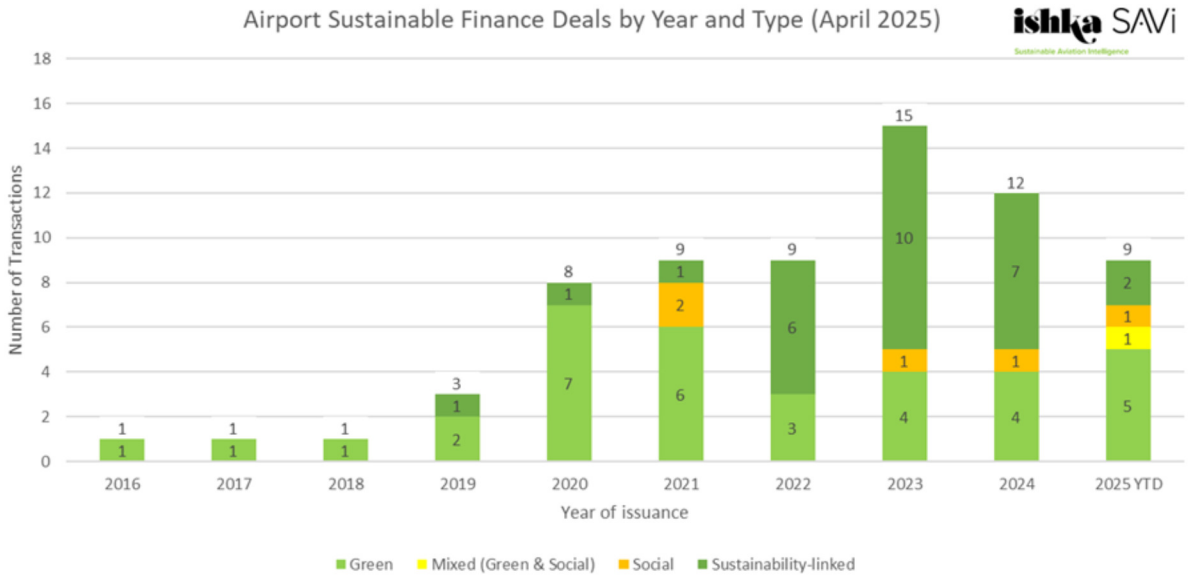
- Climb, cruise, and descent (CCD) emissions, on the other hand, go beyond LTO phase to also account for cruise, or the full duration of the

flight. This is the metric used by Heathrow Airport in its pioneering sustainability-linked bond.

LTO and cruise emissions pioneered in sustainability-linked deals

Ishka SAVi has tracked 69 airport sustainable finance transactions since 2016, spanning green (35), sustainability-linked (28), and social (6) structures. Green bonds and loans – where the use of proceeds must be linked to categories like renewable energy, clean transportation, energy efficiency, or green buildings – remain the most popular. However, and reflecting trends in the wider market, there is a growing preference for the flexibility afforded by sustainability-linked transactions, where funds do not need to be earmarked for specific uses.

Airport Sustainable Finance deals by year and type, 2016-April 2025



Source: Ishka research based on public announcements, airport disclosures, and Bloomberg. The first entry in 2016 is made up of several tranches issued between 2016 and 2018 for the construction of Mexico's New International Airport – a project cancelled in 2018. These bonds were later bought back by the Mexican government.

A key factor driving the rise of sustainable finance in airports is the ability to leverage ongoing sustainability initiatives to secure debt raises that appeal to ESG-focused investors and lenders. Many of these initiatives align with Airport Carbon Accreditation (ACA), a seven-level carbon management certification covering 618 airports across 94 countries.

In the ACA's seven accreditation tiers, its highest, Level 5 (which sits atop 1, 2, 3, 3+, 4, and 4+), comprehensively addresses Scope 3 emissions. Launched in

late 2023, it requires airports, among other achievements, to submit a verified carbon footprint for "all relevant categories" of Scope 3 and committing to Net Zero in Scope 3 by 2050 or sooner, including by developing a stakeholder partnership plan to achieve this with regular milestones in line with their sectors' Net Zero frameworks and commitments. Airports from Level 3 are also required to include additional Scope 3 emissions into their carbon footprint.

The frontrunners: Heathrow and Gatwick

Among the 28 sustainability-linked airport deals to date, all but two have been linked to emissions reductions, usually aimed at Scope 1 and 2. Eleven include Scope 3-related targets, of which five pioneering deals by two airports tacked aircraft emissions:

- London Gatwick's €750m 3.625% Sustainability-Linked Senior Secured Bond due 2033. The deal's two SPTs consist of reducing Scopes 1 & 2 greenhouse gas emissions below 1,500 t CO_2e by 2030, and achieving an absolute LTO GHG per passenger below 9.0 kg CO_2e per passenger by 2032 versus a 2019 baseline of 12 kg CO_2e per passenger (a 25% decrease).

- Heathrow Airport's Sustainability-Linked deals. In July 2023, Heathrow became the first airport to include its entire carbon footprint in the SPTs of a sustainability-linked transaction (€650m 4.5% sustainability-linked bond due 2033). One of its two SPTs targets reducing carbon emissions by 15% 'in the air' by 2030, which includes Scope 3 emissions from aircraft in the LTO cycle and cruise phase for departing flights. The other SPT targets reducing carbon emissions by 46.2% on the ground by 2030, which include Scope 1, 2 and 3 emissions from their buildings and infrastructure, Scopes 1 and 3 airport vehicle emissions, Scope 3 passenger and emissions from employees getting to the airport on surface transportation, and Scope 3 supply chain emissions. Heathrow has since used these SPTs again in December 2023 for the conversion of existing Revolving Credit Facility (RCF) and Working Capital Facility (WCF) to sustainability-linked loan structures, in December 2024 as part of a Swiss franc-denominated 1.5225% senior secured bond due 2034, and in January 2025 as part a €600 million 3.875% senior secured bond due 2038.

Besides these deals, some signs point at potential further airport issuances with Scope 3 aircraft targets. Mundys, an Italian holding company which manages Rome's two airports as well as airports in southern France, has included LTO

emissions as a relevant KPI in its sustainability-linked financing framework. In April 2025, Aeroporti di Roma (ADR), a Mundys subsidiary, also added LTO emissions as a relevant KPI to its own sustainability-linked financing framework. Meanwhile, in a sign that Scope 3 emissions are increasingly valued by investors, a S&P second opinion report for the sustainability-linked framework of Grupo Aeroportuario del Pacífico – a Mexican airport holding that went on to issue a sustainability-linked bond in February 2024 – was critical of the absence of Scope 3 targets in its framework.

The case for granular LTO monitoring

The increasing relevance of LTO emissions for airports is creating a need for more granular monitoring, but this endeavour remains relatively bespoke, with no universal preference for absolute or intensity metrics. Using location and altitude data, LTO emissions can be calculated for a given aircraft type and airport using typical periods that the engine is in each of the four LTO phases, determining fuel flow.

Emissions per movement, emissions per passenger, or absolute emissions are just some of the ways airports examine their Scope 3 aircraft emissions. Different geographies, resulting route lengths and networks or infrastructure design are some of the features that make like-for-like airport comparisons difficult.

According to PACE data, LTO emissions for an Airbus A320 during the summer of 2024 were approximately 24% higher in London Heathrow than in Brussels, largely due to longer taxiing times at Heathrow. Both airports have a comparable size of 12 square kilometers, but taxiway distances differ, Heathrow is a substantially busier airport, and Brussels has one more runway – just to name a few likely factors.

For this reason, progress to reduce LTO emissions may be best analyzed in relation to airport movements within that airport. In addition to prioritizing more fuel-efficient aircraft types, airports can aim to optimize aircraft movements to reduce taxi and idle times or encourage airlines where possible to use single-engine taxi. Eventually, solutions like in-wheel electric taxiing system WheelTug, which is aiming to be operational by 2026, will be able to further reduce taxiing emissions.

Reimagining flight: The Sustainable Aero Festival charts aviation's greener future

Lukas Kaestner

Co-founder and CCO at Sustainable Aero Lab

What are the actions that bring aviation forward? At the Sustainable Aero Festival in December 2024 in Amsterdam, the Sustainable Aero Lab interviewed leading industry executives and aerospace investors on stage over two days to hear their thoughts on the future. Additionally, more than 30 startups gave pitch presentations to the room, showcasing their technologies and products.

Throughout the event, the voices from across the aviation ecosystem echoed one clear message: sustainability is no longer optional—it is the future of flight.

From innovative aircraft designs to policy and financing strategies, the festival showcased bold ideas and collaborative approaches that are reshaping how we fly. Here are the most impactful insights from the festival's key participants.

Arjan Meijer (President & CEO of Embraer Commercial Aviation): A sustainable takeoff starts in Europe

Arjan Meijer kicked off the event by underlining Europe's responsibility to lead aviation's green transition. As a historic aviation hub, Europe is well-positioned to drive innovation and adopt sustainable technologies at scale.

Despite expected price increases, Meijer noted that passenger demand will remain strong - people want to stay connected. The challenge, then, is not reducing travel, but making it sustainable.

He emphasized the urgent need to scale Sustainable Aviation Fuel (SAF) and invest in hydrogen infrastructure while addressing the biggest hurdle: financing. Public and private investment must work hand in hand to accelerate development.

Tom O'Leary (CEO of JetZero): A radical rethink of aircraft design

Tom O'Leary, CEO at renowned California-based OEM startup JetZero, illustrated their concept of a Blended Wing Body (BWB) aircraft that could be used for passenger, cargo, and military purposes. Unlike conventional "tube-and-wing" airliners, this futuristic design offers up to 50% fuel savings using today's propulsion systems.

With a demonstrator flight planned for 2027, JetZero aims to secure more commitments from the industry (which was recently realized with the investment of United Airlines Ventures). The design is also compatible with most existing airport infrastructure and could potentially operate on hydrogen fuel over long distances.

O'Leary's summary was simple: "Embrace first-principles thinking, set ambitious goals - and have fun doing it."

Brian Moran (Chief Sustainability Officer at Boeing): Accelerating SAF adoption and fleet renewal

Boeing's Brian Moran underscored the critical need for policy changes to unlock SAF's full potential. Despite Boeing's early leadership in SAF testing, already beginning in 2008, widespread adoption remains slow.

Meanwhile, aging aircraft continue to fly, also because of the effects of the pandemic. The global fleet renewal rate dropped from 5.8% to 3.5% between 2019 and 2023, with over 3,000 outdated planes still in service. Moran stressed that replacing these with modern, fuel-efficient aircraft could yield 20–30% improvements in efficiency.

Boeing is also investing in next-generation demonstrators, setting the stage for more dramatic progress in sustainability.

Jolanda Stevens (Program Manager for Zero-Emission Aviation, KLM Royal Dutch Airlines): Taking flight with real-world trials

In her role, KLM's Jolanda Stevens is advancing tangible change through pilot programs and cross-industry collaboration. From organizing employee flights on electric aircraft to exploring battery and hydrogen options, KLM is testing innovative ideas for aviation on the ground.

Stevens emphasized the critical role of engaging the public, partnering beyond aviation, and securing government incentives in scaling innovation. Most importantly, she urged the industry to avoid overpromising while maintaining transparency.

Jan Toschka (CEO of Zaffra): The business case for scaling SAF

For Zaffra CEO Jan Toschka, the question isn't whether SAF can scale - it's how fast the industry is willing to act. He also gave a price tag, estimating that Europe needs to see €250 billion in investment by 2050 to meet its SAF targets.

While bio-based SAF is commercially viable today, synthetic fuels (PtL) offer better long-term scalability. The good news? Even full-scale adoption would only add about €10 to a passenger ticket.

Toschka argued for clear mandates, defined responsibilities, and a mindset shift, especially regarding ticket costs: "Let's take the drama out of the discussion — it's all very doable."

Axel Krein (Executive Director, EU Clean Aviation Joint Undertaking): Hydrogen, funding, and collaboration

Representing the EU's Clean Aviation Joint Undertaking, Axel Krein shared details of a €4 billion public-private effort aimed at making climate-neutral aviation a reality by 2050.

The initiative focuses on hydrogen technologies, fuel burn reduction, and non-CO_2 emissions like contrails and NOx. With €380 million in funding available in early 2025, Krein encouraged startups and SMEs to apply, especially through cross-country consortia.

"This is about more than just funding," Krein said. "It's about creating a robust ecosystem where collaboration and innovation drive us toward a sustainable future for aviation."

Matteo Mirolo (Strategy and External Relations Director, Contrails.org/ Breakthrough Energy) & Christoph Todt (Head of Environmental Sustainability, TUI Airlines): Contrails in the spotlight

Breakthrough Energy's Matteo Mirolo and TUI Airlines' Christoph Todt drew attention to an often-overlooked climate issue: contrails. These aircraft-produced clouds can trap heat and contribute as much to global warming as CO_2 emissions.

Together, they are pioneering contrail avoidance strategies by leveraging flight data and predictive modeling. Their efforts have already resulted in over 70 test flights, with more planned.

The duo called for more research, better predictive tools, and stronger policy support. Public awareness remains low, and they believe contrails must become a visible topic in climate policy discussions.

Nico Buchholz (Chief Commercial Officer, Deutsche Aircraft): Rethinking efficiency and sales

Veteran aviation executive Nico Buchholz brought a historical lens, tracing the evolution from high-speed concepts like Boeing's Sonic Cruiser to today's fuel-focused designs like the 787 Dreamliner.

Buchholz emphasized the need for 20%+ efficiency gains in new aircraft and advocated for open-rotor propulsion as a game-changer. He encouraged aircraft makers to view their planes as integrated energy systems and stressed the importance of collaborative innovation.

Notably, he reframed the business model: "In this industry, products are bought, not sold. It's about solving real customer problems."

Michael Winter (Chief Science Officer, RTX): Bridging with dual-fuel engines

Renowned propulsion specialist Dr. Michael Winter made a compelling case for dual-fuel jet engines - combining hydrogen and kerosene - as a transitional solution while infrastructure catches up.

With jet engine efficiency already improving 450% over the past 85 years, the real challenge still lies ahead. Winter believes the next frontier is optimizing propulsive and thermal performance. He also forecasted the emergence of hybrid-electric systems in the late 2020s and hydrogen propulsion by the early 2030s. This could also mean a renaissance of turboprops.

With regulatory support for 100% SAF usage underway, these fuels remain a critical bridge toward a greener future, allowing airlines to decarbonize using existing infrastructure.

VC Panel: Funding the future of flight

A panel of leading investors from JetBlue Ventures, NATO Innovation Fund, RTX Ventures, and Honeywell Ventures offered guidance for aviation startups:

- Start early: Build investor relationships well before you seek funding.
- Know your audience: Understand each VC's focus—whether it's SAF, hardware, or dual-use tech.
- Tailor the ask: With check sizes ranging from $1M to $15M, startups should tailor their pitch accordingly.
- Seek strategic partners: Co-investment offers not just money, but market expertise.

Their central advice? "Trust and timing matter as much as technology."

Conclusion: A shared mission, a clear path

The Sustainable Aero Festival made one thing clear: the path to sustainable aviation is collaborative, ambitious and entirely within reach. Challenges like cost, regulation, and infrastructure remain, but the combined will of innovators, airlines, investors, and governments would be enough to propel the industry forward.

With breakthroughs in aircraft design, fuel innovation, and emissions management—backed by a growing pool of funding—aviation should strive not just to survive, but to lead in the global transition to Net Zero and to regain the pioneering role, which it once already had until the 1970s.

The next great leap in flight should not be higher or faster - it will be cleaner, smarter, and shared.

Can improving airline on-time performance (OTP) help reduce emissions?

Andrew Doyle

Senior Director Strategy at Cirium

Cirium has focused on the routes with biggest tracked gate-to-gate time reductions which also had reductions in CO_2 intensity and then looked for on-time performance

Cirium's EmeraldSky emissions methodology has for the first time revealed an underlying link between airline on-time performance (OTP) and reduced flight emissions. While it should be cautioned that many factors influence both emissions and OTP, our hypothesis was flight routes that delivered the strongest year-on-year improvements in OTP were typically subjected to fewer enroute delays with engines running, during both the ground taxi and airborne phases.

EmeraldSky considers a wide array of variables when estimating CO_2 emissions for each flight. From the type of aircraft and engine series to winglet design, passenger and cargo payloads, and even the age of the airframe – it's all factored in. Crucially, EmeraldSky also includes real-time data like gate and runway times, allowing for an accurate record of how long planes spend taxiing and flying. Time spent in the air or taxiing obviously directly impacts fuel burn – and therefore CO_2 emissions.

Cirium analyzed airport pairs less than 1,500km (800nm) apart with more than 500 monthly flights – comparing data from July 2024 with July 2019 – and ranked them by percentage reduction in average gate-to-gate time. We then took the 15 routes that had the biggest reductions in block times as well as reductions in total CO_2 emissions and measured their OTP performance.

Using this approach, eight routes showed improved OTP coinciding with significant reductions in average flight times and emissions. Conversely, using the opposite logic, nine routes showed longer average sector times, increased emissions intensity, and declining OTP.

Although this analysis did not consider factors such as equipment changes, the findings nevertheless uncontroversially highlight the importance of addressing inefficiencies in air traffic management (ATM). For instance, the slow progress in integrating nationally controlled airspace over mainland Europe is a well-known bottleneck. These inefficiencies not only drive-up fuel burn and emissions but also limit airlines' ability to improve OTP.

More details about EmeraldSky are available here.

From transition to delivery: Lahiru Ranasinghe on steering easyJet's decarbonization effort

Eduardo Mariz

Sustainability Lead and Senior Analyst at Ishka

*With questions by **impact's** Reporting Workstream*

Photo: Eduardo Mariz (left) and Lahiru Ranasinghe, Director of Sustainability at easyJet (right).

As easyJet's recently promoted Director of Sustainability, Lahiru Ranasinghe is now overseeing the decarbonization journey for one of Europe's largest airlines, which is facing unique challenges like phasing in SAF and fuel-saving efficiency efforts across a vast multi-base operation. After spending some considerable time developing the airline's Net Zero roadmap, Ranasinghe says the time for delivery is now. "Our job here is not to keep developing and redeveloping a [Net Zero] strategy, it's to make sure that we can develop the capability in the business and start delivering against that strategy," he tells ***impact***.

In conversation with ***impact***, Ranasinghe unpacks near-term decarbonization hurdles, longer-term priorities like the e-SAF and hydrogen scale-up, and how the airline keeps track of its Net Zero progress.

The evolution of a role

Ranasinghe's path to Director of Sustainability mirrors that of many industry peers – a budding passion for aviation that grew into a career in the airline industry, ultimately leading to drive broader positive change. "While I was in the strategy team, the sustainability team at easyJet needed some help in terms of developing a Net Zero roadmap, because they needed to bring that capability into the team. So, I stuck my hand up," he recounts.

"I was the Head of Net Zero previously, [a role] which was very much focused on the decarbonization aspects of flying […] very strategic, very analytical. Now, moving into the Director of Sustainability role, I've got responsibility for the whole suite of environmentally-focused sustainability issues and matters in-the-air and on-the-ground." Naturally these initiatives are not limited to the sustainability team and many are delivered by teams across the business such as Flight Operations, Engineering, Fuel.

Over time he has witnessed the role of the sustainability team evolving from a primarily compliance- and reporting-focused function to a more "strategic" role and eventually transitioning into a "delivery" phase.

Squeezing more from what they have

With the global aircraft supply chain still recovering from pandemic-era disruptions, fleet renewal has been slower than many airlines, including easyJet, anticipated. "It's not ideal because clearly any flying that we are doing on an [Airbus A320] ceo versus a neo aircraft is less efficient […], but it's not something that turns the plan on its head because we already have a relatively young and efficient fleet."

Although there are some delivery delays, the airline has been delivering well on operational efficiencies – a particularly important aspect of its operations given the challenging environment in which it operates. "We possibly have a larger operation in congested airspace and in constrained airports than any other airline in the world," Ranasinghe explains.

However, there are limits to how much fuel efficiency an airline can achieve independently using current aircraft technology, making further airspace modernization essential, he emphasizes. "If we are able to deliver as an aviation ecosystem the 10% fuel and emissions savings through modernization of airspace, that is absolutely massive, because that doesn't just reduce 10% of emissions, that also takes 10% of the SAF supply chain requirements, the hydrogen supply chain requirements, the eventual carbon removals requirements," he points out. The airline is actively involved in EU-funded initiatives such as HERON, which focuses on implementing more efficient flight paths, and IRIS, which enhances air traffic management communication via satellite.

Fuel burn reductions are also about cost savings. Approximately 80% of easyJet's operations are subject to SAF mandates in Europe and are covered

by the EU, UK, and Swiss ETS. "Making flying more sustainable does carry a cost, but we also have to make sure that we are still able to do this [as a business], without it being at the cost of easyJet's mission, which is to keep flying affordable."

Replacing jet fuel with SAF

Besides reducing its fuel requirements, easyJet is also working on replacing a higher share of its jet fuel with SAF. "We are a point-to-point carrier operating from over thirty bases across UK and Europe. Currently we work with our fuel suppliers to buy fuel that is compliant with the mandates", Ranasinghe notes.

One area where easyJet is particularly active is e-SAF policy engagement. The carrier is among the few airline members of Project SkyPower, a group of leaders across the aviation value chain working to help first-of-a-kind e-SAF projects achieve FID.

easyJet's commitment to long-term sustainable energy solutions for aviation also includes hydrogen, which it sees as "the only option for us as an industry to have truly zero carbon emissions flight." "Our average sector length is around two hours. So we've got short sectors, we've got a large fleet, and that lends to the kind of capability to be able to use hydrogen in a narrowbody short-haul operation."

Measuring progress, comparing peers

In the near-term, easyJet's primary metric for tracking decarbonization progress remains emissions intensity. "We monitor performance against the key performance indicator, which is the carbon intensity or the greenhouse gas intensity in CO_2e/RTK. It's an interesting one because while we get a view of this on a monthly basis, initiatives that are driving the change in intensity such as fleet and operational improvements require quite big structural changes, so change takes time."

"We want to ensure we're doing the best we possibly can so we of course keep a close eye on the activities of other airlines through resources like annual reports. But with sustainability, we celebrate the successes and performances of any other carriers as this is a problem that we face and have to address as an industry," Ranasinghe adds.

"From our perspective, decarbonizing the industry is essential as it gives us our license to operate, because we cannot afford to be one of the few heavy

emitters left in the world when we get into the 2040s, 2050s. There's a lot at stake."

Watch the video of the interview with Lahiru Ranasinghe here.

impact Members' Call presentations

In the first half of 2025, we had the pleasure of welcoming a variety of expert speakers on our bi-weekly members' calls to present on topics relevant to the decarbonization of the aviation industry.

"The realities of the energy transition"

Ehsan Khoman

Head of Research - Commodities, ESG and Emerging Markets (EMEA) at MUFG

Global investments in the energy transition continue to reach unprecedented levels, with significant growth driven by advancements in renewable energy, electrified transport, and emerging technologies such as hydrogen and carbon capture. Investment in sustainable solutions has surpassed spending on fossil fuels, reflecting a strong commitment from public and private sectors. Meanwhile, the aviation industry's journey to Net Zero by 2050 remains complex, with emissions growth outpacing efficiency gains despite progress in areas like sustainable fuels and fleet modernization. Achieving a cost-effective transition requires coordinated actions, prioritizing impactful measures, and addressing knowledge and investment gaps across the ecosystem.

"Introducing the European Hydrogen Bank: Accelerating the establishment of a full hydrogen value chain"

Javier García Fernández

Policy Officer at DG CLIMA / European Commission

Javier provided an overview of the EU's Innovation Fund and explored the 2024 Innovation Fund Calls, including regular grants, competitive auctions, and other financial instruments available to industry stakeholders. Additionally, he highlighted successful aviation-related projects supported by the Fund, offering key insights for potential future applicants and interested parties.

"Update on the EU Competitve Compass"

Emma Giddings

Partner at Norton Rose Fulbright

Emma gave an introduction to the EU Competitve Compass and shared the latest updates.

"Considering technology characteristics to project future costs of direct air capture"

Katrin Sievert

Research Associate and PhD Candidate at ETH Zürich

Katrin Sievert shared insights on the future costs of Direct Air Capture (DAC), uncovering key drivers and uncertainties that will shape its economic viability. Using technology learning curves, the analysis projects cost trajectories for different DAC approaches. The talk concluded with an exploration of DAC's role in aviation, comparing its potential for synthetic fuel production (DACCU) and carbon removal offsets (DACCS) in achieving climate neutrality.

"Update on the EU Commission's Omnibus proposal"

Lorraine McCann

Managing Director Sustainable Futures at KPMG

Lorraine McCann provided a brief update on the EU EC's Omnibus package and its impact on lessors' reporting obligations.

"How to speed up aviation's path to climate-neutrality with Power-to-Liquids (PtL)"

Regina Pouzolz

Director of Sustainable Flight at Deutsche Aircraft

Regina Pouzolz addressed the impact of aviation emissions on climate change and discussed the basics of aircraft design for a deep-dive into the opportunities and limitations of electric aircraft as well as the relevance of SAF as the key lever to minimize aviations' climate impact. In this content, Regina introduced the CLIM0ART project, a PtL-proxy flight test campaign by Deutsche Aircraft, German Aerospace Center (DLR) and Sasol.

"CFM actions towards a more sustainable aviation"

Sandrine Lacorre

Product Marketing General Manager at CFM International

The presentation highlighted CFM's initiatives aimed at improving the environmental impact of aviation. These initiatives include advancements in new engine technologies and architecture, the development of hybrid-electric systems, research and experience in hydrogen and compatibility with sustainable aviation fuels.

"Climate change and aviation 360°: ESG fatigue, addressing non-CO_2 emissions, adaptation strategies"

Maxime Meijers

CEO and Co-Founder of Estuaire

In his presentation, Maxime offered a comprehensive exploration of the evolving climate challenges facing aviation, moving beyond a narrow focus on emissions. He addressed ESG fatigue, discussing how aviation stakeholders can recalibrate environmental strategies to sustain credibility and engagement. Maxime also focused on the growing importance of non-CO_2 emissions—including contrails and nitrogen oxides—as high-impact climate agents, often overlooked in traditional mitigation efforts. Finally, he examined climate adaptation strategies, highlighting risk assessment methodologies, airport resilience planning, and the impacts on airlines of increasing weather phenomena.

"How domain-trained AI can make the difference in an airlines' journey toward efficiency and sustainability"

Chris Brown

Partner at KPMG Ireland

Stéphane Nitenberg

SVP Strategic Partnerships at OpenAirlines

Artificial Intelligence's capacity to analyze extensive data, identify patterns, and make informed choices is paving the way for new possibilities to enhance operations and fuel efficiency. In this presentation, Chris Brown opened the call with a high-level market overview, outlining how AI is being deployed across the aviation value chain. Stéphane Nitenberg (OpenAirlines) explored how AI transforms data analytics and revolutionizes

decision-making processes. He also explained how AI-driven insights can maximize fuel efficiency and drive sustainable practices.

"SAF financial value chain risk management as the key to unlock producer FIDs"

Arnaud Namer

CEO and Co-Founder of ATOBA energy

ATOBA is the midstream sustainable aviation fuel (SAF) aggregator accelerating the aviation industry energy transition through solving the SAF financial dilemma between airlines and producers. ATOBA brings high security and competitiveness to the SAF supply chain for its airline partners, while providing producers with long-term offtake agreements that unlock their Final Investment Decisions.

"An update on CORSIA"

Lev Gantly

Partner at Philip Lee LLP

Adelfio Ronci

Director Environmental Products at ICE

The presentation gave an overview of CORSIA's role in aviation sustainability, highlighted recent technical and legal updates, and outlined possible EU positions. It also covered trends in supply, demand, and pricing for CORSIA credits, explored how lenders and lessors can support these efforts, and concluded with a Q&A session.

impact is a non-profit platform for investors in and financiers of airlines and aviation infrastructure aiming to be at the forefront of a new reality in aviation finance. ***impact*** is comprised of six collaborative working groups designed to deliver a credible and transparent roadmap to reduce CO_2 emissions from aviation to Net Zero by 2050. ***impact*** is funded by the pro bono contributions of members, including a group of leading global financiers in aviation.

Learn more on: www.impact-on-sustainable-aviation.org

impact on sustainable aviation e.V.
Berliner Str. 72
60311 Frankfurt am Main
Germany

info@impact-on-sustainable-aviation.org