impact

ON SUSTAINABLE AVIATION

July 2024

Insights 2024

impact
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Foreword by Ulrike Ziegler - Chairperson of impact Board

Dr. Ulrike Ziegler,
Chairperson of impact Board

Dear Friends, dear Colleagues,

It is with great pleasure that we share the second edition of "impact – insights" – just in time for the Farnborough Air Show to provide food for thought and discussion.

Yet again, "impact – insights" features valuable contributions from the expert community on a broad array of subjects, ranging from investors' views on sustainable aviation investment or the need for resolute action to achieve climate neutrality, to views on the relevance of net zero and sustainable finance in Japan and China respectively.

The topics covered in "impact – insights" reflect the extent of our talks with industry partners and within our ever-growing stakeholder network. It is fair to say that we, impact, have truly increased our industry relevance and established ourselves as a key enabler of sustainability in aviation, as evidenced by our numerous speaker roles at principal industry events. Founded only two years ago, our success is also reflected in our growing number of supporters at over 40 members.

But connecting with other stakeholders can only take us so far – it is also high time to translate words into action and progress. Many people speak loudly on the necessity to cooperate and collaborate, but this must go beyond a mere ambition. We, at impact, are in the midst of doing just that: forming alliances with relevant parties to take stock of the industry's decarbonization and to complement each other's skill sets and reach.

We must understand the status of the industry's decarbonization efforts. Where are we in our endeavors? Are the widely referenced decarbonization wedge chart roadmaps truly guiding the way? We believe that these handy roadmaps, which are projections only, provide a false sense of security. A hard landing will become a reality unless we transition from mere "cooperation" talk to actual stocktaking and radical collaboration on solutions. The question is: Do we, as an industry, dare to truly take stock?

As a facilitator we at impact are determined to not sit idle, but to take the lead. We will make an appraisal of the industry's decarbonization efforts and shape the conversation between the magic square of science, regulation, industry, and finance. Not only is our intention to spotlight the key gaps to effective decarbonization, but also to contribute to the development of effective strategies and coordinate real-world action to 2030 by relevant stakeholder groups. The time to act is now.

In the meantime, the pressure on the industry is increasing. Recent greenwashing claims against more than 20 airlines in Europe are only one example for what is to come as regulators examine the industry's decarbonization efforts in closer detail. Not decarbonizing will be far more expensive, potentially resulting in stranded assets and the deterioration of asset values. The additional expenses of transitioning to SAF or relying on carbon capture and other technologies will be dwarfed by the price of not decarbonizing fast enough.

The aviation sector has been synonymous with progress and global connectivity for over half a century. And we, at impact, are convinced that the industry is willing and able to continue its path successfully while assuming environmental responsibility.

Before I close let me extend impact's sincerest gratitude to:

- the interviewees and parties that have contributed to this edition of "impact – insights",
- impact members for your continued support and, in particular, workstream members who invest a substantial amount of their time, and to
- Philipp Goedeking and Peter Smeets, founding members of impact, for your excellent service on impact's Board of Directors until very recently. Without you, we would not be where we are today.

Last but not least, on behalf of the impact Board of Directors, I would like to extend a warm welcome to Michael Halaby, MUFG, and Bryson Monteleone, PwC, our newly elected board members replacing Philipp Goedeking and Peter Smeets, who have left big shoes to fill. With the long-standing expertise of Michael and Bryson, and the continued support of Philipp and Peter as members of our workstreams, the cause of impact will advance even further.

We look forward to continuing the dialogue with all aviation stakeholders across regions and broader groups. Together we can!

1. Experts featured in H1 2024 members' calls

impact welcomes industry leaders to its biweekly members' calls for presentations on topics relevant to aviation's decarbonization.

In the first half of 2024, our members' calls featured the following experts and topics:

'EU ETS for aviation update and airline SAF contracts'

Damien Meadows & Barry Moss

Damien Meadows
Advisor on European and International Carbon Markets European Commission, DG Climate Action

Barry Moss
Managing Director AVOCET and Co-Chair & Founder of PACE

In this presentation, Damien provided an update on EU ETS support for the use of alternative fuels, i.e. through the Innovation Fund. Barry introduced the EU ETS free SAF allowances and current market pricing system.

‘SkyFuelH2 – what does it take to enable a future of SAF beyond HEFA’

Catherine Smitt-Meyer

Catherine Smitt-Meyer
Innovation Manager
Uniper

The ReFuelEU Aviation regulation was adopted in 2023, mandating a minimum share of SAF in 2025, and introducing sub-quotas for synthetic fuels from 2030, with heavy penalties for non-compliance. This talk focused on what it takes to make production of the next generation of SAF possible. Catherine laid out concrete steps in one of Uniper’s projects, from finding the right site, establishment of raw material supply chains, partnerships, and preparing the project for project financing.

‘Ishka SAVi introduction and recent trends’

Eduardo Mariz

Eduardo Mariz
Senior Analyst & Sustainability Lead
Ishka

Upon members’ request, Eduardo Mariz, Sustainability Lead at Ishka, introduced Ishka SAVi, a data and intelligence platform dedicated to aviation sustainability launched at the start of 2024. In his talk, Eduardo presented the functionalities of the SAVi platform and provided an overview of analytical reports and data dashboards, particularly those focusing on SAF. He also provided a quick overview of recent developments in aircraft technologies and trends in aviation ESG data.

'Reducing Emissions: Near-term solutions'

Isaiah Cox & Santi Lopezbarrena

Isaiah Cox
CEO
WheelTug

Santi Lopezbarrena
Sustainability Manager
Vueling Airlines

Vueling and WheelTug shared practical, cost-effective, and near-term ways to reduce fuel burn and emissions. E-Taxi (aircraft ground taxiing using electrical power) makes operations cleaner and greener and enhances aircraft residual value.

Vueling is actively working to achieve net zero emissions by 2050 and is doing so by working on supplying more Sustainable Aviation Fuel (SAF), working on operational efficiency measures, and improving the efficiency of the fleet. Vueling has also partnered with WheelTug to accelerate the development of its electric taxiing device as part of the many operational measures the airline has in place or is planning to implement.

'Towards an investible SAF sector: The role of price support mechanisms'

Josh Garton

Josh Garton
Head of Financial & Investment Analysis
Green Finance Institute

Josh provided a review of the investment risks associated with SAF production, with a focus on price risk and the price support mechanism the UK government is considering to address price risks.

‘The real cost of green aviation – ramp-up, mark-up, prerequisites’

Dirk Niemeier & Anna Went

Dirk Niemeier
Director & Lead for Clean Hydrogen Solutions
Strategy& PwC

Anna Went
Senior Associate
Strategy& PwC

Everyone is talking about sustainable aviation fuels (SAF) and their significance for emissions reduction. But what are the actual cost implications of SAF for European airlines and their customers? Based on a scenario analysis by PwC, Dirk and Anna made statements on possible cost break-even points, evaluated ramp up dynamics and calculated cost impacts for airlines and their customers.

‘Next generation hydrogen and cellulosic waste-to-fuels for aviation’

Chris Chaput

Chris Chaput
President & CFO, DG Fuels

Chris provided an update on DG Fuel’s SAF plant project and discussed real-life challenges on the path to project implementation. DG Fuels is executing on its plan to be the most scalable and lowest cost zero carbon SAF producer. Its high carbon conversion efficiency approach allows it to meet these goals while providing an attractive return to capital investors with substantial growth potential. The company plans on producing SAF from biomass and waste feedstocks combined with the use of hydrogen.

'The challenges and opportunities to decarbonize aviation'

Andy Shafer

Andy Shafer
Chief Customer, Marketing and Brand Officer
Gevo

Andy Shafer of Gevo provided an overview of the firm, a carbon abatement company, and perspectives on the challenges of decarbonizing aviation. Andy highlighted the various technical opportunities and the challenges each face, discussed the relative competitiveness of each of these technologies and compared them with incumbent jet fuel. Andy's talk also provided an overview of Gevo's Net Zero 1 SAF plant, expected to be the first commercial global scale Alcohol-to-Jet SAF production plant. The talk also examined Gevo's Verity Carbon Tracking business, an integral part of ensuring and validating carbon abatement.

'Regenerating regional flying: Introduction to Heart Aerospace and the ES-30'

Simon Newitt

Simon Newitt
President & CCO
Heart Aerospace

The regional aviation segment is shrinking and faces existential pressures, meanwhile battery-electric and hybrid-electric aircraft provide a proposition to reverse this tide in the shortest time. Electrification is already underway, creating a more manageable path to operational reality.

'CSRD Overview and reporting'

Lorraine McCann

Lorraine McCann
Managing Director Sustainable Futures, KPMG Ireland

Lorraine specialises in supporting clients with sustainability regulatory compliance, including the Corporate Sustainability Reporting Directive (CSRD), International Sustainability Standards Board (ISSB), US Securities and Exchange Commission (SEC) Climate Disclosures, and Taskforce on Climate Related Financial Disclosures (TCFD), to name a few. In this talk, Lorraine provided an overview on the task ahead for companies in the scope of CSRD to become compliant.

'SkyNRG's Sustainable Aviation Fuel Market Outlook 2024'

Anna Liznerova

Anna Liznerova
Senior Analyst Business Development, SkyNRG

The SkyNRG Sustainable Aviation Fuel Market Outlook covers the current state and trends of the Sustainable Aviation Fuel (SAF) market in the EU and UK, the US and rest of the world by assessing announcements of SAF projects and mapping out the capacity until 2050. This global outlook covers upcoming mandates and regional developments offering comprehensive insights. For more information you can download SkyNRG's SAF market outlook 2024 here: https://skynrg.com/skynrg-releases-sustainable-aviation-fuel-market-outlook-2024/

2. Insights from the impact workstream leads

impact speaks to the leads of three of its workstreams – Transition Finance: Lessors, Science, and Reporting – to learn more about their motivations and how impact's work supports their organizations.

Why did your organization join impact?

Patrick den Elzen (Arena Aviation Capital), lead of the Transition Finance: Lessors workstream: At Arena Aviation we believe in the necessity to ultimately decarbonize the industry and do our part in that and it's a huge challenge. And there are many obstacles to overcome, but we believe that a critical part of the solution is incentivizing and rewarding airlines for being on the right trajectory, on the right path. And so, what we can do is invest time and energy together with other lessors and financiers in impact to create a generally accepted, credible and effective sustainability-linked leasing and financing standards – a framework that everybody can abide with. That's the reason why we joined impact in particular.

Prof. Dr. Tom Conlon (University College Dublin), lead of the Science workstream: UCD joined impact to contribute to the long-term sustainability journey of aviation and to ensure our curriculum and research is informed by the latest ideas in aviation financing.

You took over the lead of the 'Transition Finance: Lessors' workstream more than a year ago. What was your personal motivation or interest to support this particular workstream?

Guido Schmitz (MUFG), lead of the Transition Finance: Lessors workstream: I think a self-organized initiative like impact lives from people taking the lead and taking responsibility, and that was one of the motivations for me, because I'm happy to do so and drive things forward. And then, the Lessor workstream in particular is of interest to me since the global aircraft fleet now is roughly close to 50% owned by lessors, and for some individual aircraft types it is already exceeding that. So, if we want impact and a standardization to be successful, we need to have a solution for that segment and not just airlines. Finally, working together with joint leads like Claudia [Ziemer] from Azorra or Patrick [den Elzen] from Arena is also a huge motivation. We can look at the lessor topic from different angles and, also personally, I highly appreciate working with experts like them and having solid exchanges on the topic.

What are the objectives of your workstream and what are the relevant achievements so far? What's next?

Guido Schmitz (MUFG): The objectives are twofold. From a financiers' point-of-view, to find appropriate KPIs to assess the progress of lessors or certain portfolios on their way to net-zero. And the second objective is, looking at it from the lessors' perspective, establish how to best measure the airlines in their portfolio and what kind of reporting requirements they can incorporate into their lease contracts with airlines.

The positive outcome so far has been establishing that impact's KPIs and concepts (absolute intensity, emissions, decoupling, milestone concept...) can also be applied to lessors and asset managers. And that is very helpful.

What feedback have you received from clients on your impact membership?

Patrick den Elzen (Arena Aviation Capital): As confirmed by a fair number of financiers and lessors discussions with airlines and investors are still very focused on the structure and the pricing of a transaction, the topic of sustainability has yet to attract more limelight. Within the Transition Finance Lessors workstream, our task for this year is to develop an action plan on how to approach other leasing and asset management platforms to win them over to the good cause. And make sure that, together with impact, we develop that much-desired sustainability-linked framework for the industry. So, receiving more feedback is our task for this year.

What are the topics you consider most relevant for impact to deal with in order to help its members and the aviation finance industry to progress decarbonization?

Matthias Reuleaux (NordLB), lead of the Reporting workstream: Decarbonization is a fairly new feature in the industry in terms of top-ranked topics and therefore the expectations of the different participants in the industry in terms of what is a "must-do item" and what is commercially prohibitive tend to get tackled from a rather extreme angle in each case. There needs to be an initiative which targets setting a level-playing-field and an intersection which reflects demands and needs of each industry member, the consumers and the planet. Otherwise, no compromise will be established and that is what is needed. Impact can add true value in the process of determining a framework that ultimately might become "the" intersection. Although impact is stemming from the lending and lessor community, its members are cognizant of the harm aviation causes to the planet and value the need to adjust the aviation industry. At this stage of the process, it is paramount to work towards a mutually satisfactory framework and a forum like impact is best suited to support establishing such intersection.

How relevant is sustainability and the progress of such to your clients? And have you witnessed an increasing interest?

Guido Schmitz (MUFG): I think it's fair to say that it's still regionally different. With European regulation, clients are mostly more advanced whereas when you visit or speak to clients in the Americas or in APAC, they're lagging behind. It's not yet an important topic. In the meantime, most market participants, whether it's airlines, lessors, financiers... has established some kind of reporting process, but they are still pretty diverse in quantity and transparency. Everyone, I would say, has taken more or less a first step, and you now people are starting to look standardization in such reporting. And that's where impact comes in: standardization and transparency. Without certain benchmarking of the industry and without transparent measurements of progress, sustainable aviation is simply not possible. So, the mission of impact remains important in the sector.

Market participants also have a certain interest in aligning reporting and measurements, because if you are lagging behind, you might be accused of greenwashing. So that alone drives people at least to engage with you and try to, at least, reach a minimum standard. Whether we want it or not, the topic of sustainability will not go away.

Why should banks and lessors implement the milestone concept in finance contracts? How could we overcome the concerns?

Prof. Dr. Tom Conlon (University College Dublin): Banks and lessors should implement the milestone system because of its simplicity, resilience to greenwashing and ability to promote long-term investment. To overcome the concerns, we need to understand the concerns.

How is impact perceived at your organization? What does your management perceive as an added value?

Matthias Reuleaux (NORD/LB): NORD/LB has developed a strong focus on becoming a market leader in the lending industry for wind and solar energy projects and thus sustainability is a high priority. With that in mind it was obvious that other businesses like aircraft finance had to follow suit and contribute to the establishment of a framework that is committed to fostering sustainability. Against this background the management appreciated NORD/LB joining IMPACT as part of its general approach to align its lending business with the demands of sustainability, a consideration which is echoed by other IMPACT members. Whilst NORD/LB has taken the strategic decision to exit its aircraft finance business early this year it will be of utmost importance to seek alignment across the broader aviation finance community to aid the transition of the industry.

What industry challenges, with regards to sustainable aviation, do you anticipate in the near term, and how will they impact your organization? How can impact be effective in addressing these challenges?

Patrick den Elzen (Arena Aviation Capital): The near-term challenges are, in terms of sustainable aviation, how do we get enough SAF into this world and how do we get the Capex required to build up sufficient SAF production facilities. And there are certain technological challenges to further develop certain future SAF pathways and the industry should be looking for less scarce feedstock, requiring more efficient ways to produce SAF. Those are all challenges because the current technologies are not going to be sufficiently scalable given biogenic waste[1] feedstock scarcity to meet the demand. And in the longer term we have the challenge to develop hydrogen, electric or hybrid-electric aircraft. Those challenges will be more difficult to overcome if there are no generally accepted, credible, and effective sustainability-linked leasing and financing standards.

[1] Biogenic waste includes forestry and agricultural by-products, municipal waste or industrial waste like residues from vegetable processing or biodiesel production.

Without them and their financial incentives, it will just be less attractive for the industry to, for example, adopt or commit to sufficient SAF offtakes or, in the longer-term, commit to new-technology aircraft and engines. And a small leasing platform like ourselves, we don't make the market, we have to follow it. And we don't have a budget to materially invest, for example, in SAF production. But by being an active impact member, we try to make an effective contribution to address all the big challenges. So, it's not impacting us directly in our day-to-day business yet, but it will be. And it's always better to be part of the solution than to live by the solution.

What kind of thematic messaging could impact provide to help progress the discussions around sustainable aviation?

Prof. Dr. Tom Conlon (University College Dublin): The theme that keeps emerging, as I see it, is ‚how can we actually get sustainable aviation financed'. There is plenty of discussion around sustainability and lots of good ideas, but the actual flow of capital does not currently match the ambition. How do we derisk investment and promote the long-term flourishing of technological disruption in aviation?

3. An experiment in policy effectiveness – different approaches to supporting SAF scale-up between the EU and USA

Kata Cserep & Sabire Ipek Demir
with contributions from Grant Gunter and Elliott Fricker

Kata Cserep
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Summary

The need to scale up sustainable aviation fuel (SAF) investment, production and usage is evident, as one of the key pillars of decarbonizing the aviation industry. Despite industry goals and commitments and declared interest from lenders and investors to finance the energy transition in aviation, production capacity and SAF uptake remain stubbornly below 1% of total aviation fuel usage today.

Government policies and regulations are pointed to as the missing link, helping to provide the catalyst for investment and offtake commitments, so economies of scale can be unlocked for self-sufficient SAF supply demand dynamics from 2030 onwards.

This short paper compares the differing policies emerging from two of the largest aviation markets in the world – the USA and the EU. Several other factors play a part in defining a 'good' investment in SAF – availability and cost of feedstocks, cost and access to renewable electricity, technology risks etc. – and these are not discussed in detail here, unless they link directly to policy measures.

While still too early to say whether there is a clear winner in terms of policy effectiveness, there are signs that ongoing policy support will be required to help achieve the industry's stated decarbonization goals.

1. Introduction

The global aviation industry has set ambitious goals and commitments to leverage sustainable aviation fuel (SAF) as a key component of the decarbonisation strategy. Major industry stakeholders, including airlines, aircraft manufacturers, and international aviation organizations, have pledged to achieve net-zero carbon emissions by 2050. These commitments are supported by policies and initiatives from governments worldwide, aimed at accelerating the development, production, and use of SAF. The objective is to make SAF a viable and substantial part of the aviation fuel supply.

SAF is widely recognized as a crucial element, and certainly the most readily available interim solution, to decarbonize flight emissions. Other solutions include aircraft technology innovations (from more fuel-efficient aircraft designs, to innovation in lightweight materials and advanced aerodynamics to reduce fuel consumption, all the way to switching to hydrogen, electric, or hybrid-electric propulsion systems in aircraft), operational efficiencies (such as optimizing flight routes and traffic management to reduce fuel burn, continuous descent and ascent operations to minimize fuel use during take-off and landing, and more efficient taxiing and reduced engine idling) and carbon trading and offsetting (including emissions trading systems to incentivise emissions reductions).

By utilizing feedstocks such as waste oils, agricultural residues, and other renewable resources, SAF can lower lifecycle greenhouse gas emissions compared to conventional jet fuels and enable low-carbon air travel. Despite the strong interest in and support for SAF, progress in its adoption has been limited so far. The production of SAF is currently insufficient to meet the industry's needs, hindered by high production costs and limited production facilities.

A key hurdle in scaling up SAF is the necessary investment in at least several hundred SAF production facilities, which several initiatives are working to address, including impact on sustainable aviation e.V. At the project level, policy context is considered critical, as it can help mitigate some of the risks associated with financing new SAF facilities.

Although the industry has had a global carbon goal since 2021, regulatory frameworks and incentives necessary to scale up SAF production and use are still in the early stages of development in many regions. As a result, the integration of SAF into the aviation fuel mix has been slow, and significant challenges remain in achieving the widespread and consistent use of these sustainable fuels across the global aviation industry.

In this paper, we explore different approaches to supporting SAF scale-up between the European Union and the United States.

2. A reminder on pathways, availability and production cost levels

There are a variety of methods to produce SAF from renewable or waste materials, which mean they will have very distinct feedstock availability, environmental impact, and production costs. Hence, they also receive differing investment and policy support. The alternative production methods are referred to as 'pathways'. Key SAF pathways include:

1. Biofuels

a. Hydroprocessed Esters and Fatty Acids **(HEFA)**: The most mature SAF pathway, converting waste oils, fats, and greases into jet fuel through a hydrogenation process.

b. Alcohol-to-Jet (**AtJ**): Converting alcohols (ethanol or butanol) derived from biomass into jet fuel through a series of chemical reactions including dehydration, oligomerization, and hydro genation.

c. Fischer-Tropsch (**FT**) Synthesis: Gasifying biomass, municipal solid waste, etc into syngas (a mixture of hydrogen and carbon monoxide), which is then converted to liquid hydrocarbons through the FT process.

d. Gas-to-Liquids Fischer-Tropsch Synthesis (**G-FT**): Converting natural gas (or biogas) into liquid fuels through reforming to produce synthesis gas (syngas). The syngas is fed into F-T reactor and converted to long-chain hydrocarbons through a series of chemical reactions, and then refined into synthetic fuels.

2. Power-to Liquids (PtL)

a. Electrofuels: Using renewable electricity to power electrolysis and produce hydrogen from water, and then combining the H2 with carbon dioxide (captured from industrial processes or directly from the air) to produce synthetic jet fuel.

There is a range of pathways to SAF, but significant volumes of all fuels will be required to meet rapidly growing demand. These pathways vary in their financing requirements and future availability. HEFA is currently the most viable pathway in terms of cost and technology maturity, however this will change over time due to limited available feedstock in 2035. PtL is the pathway that will help decarbonise aviation the fastest, but it currently has the highest production costs (due to the high cost of green Hydrogen as it requires abundant renewable energy).

	Supply drivers					Demand drivers	
	TRL[1] in 2023	Blending limits	Feedstock availability in 2035	Commercial production start forecast	Producers (not exhaustive)	Carbon reduction	Current Production cost vs. jet fuel
HEFA	8 – 9 System test, launch & Operations	10% - 50% dependent on feedstock	Very Low 1x-0.6x demand	Now	NESTE, world energy, H-C-S GROUP	53 - 79% dependent on feedstock	*[lowest cost SAF]* 2x
AtJ	6 – 7 Technology demonstration	30%	High[2] 140x-50x demand	by 2025	LanzaJet, gevo, Axens	30 - 67% dependent on feedstock	5x
G-FT	6 – 7 Technology demonstration	5% - 50% dependent on feedstock	High 80x-40x demand	by 2025	VELOCYS, FULCRUM, RED ROCK BIOFUELS	56 - 91% dependent on feedstock	4x
PtL-FT	6 – 7 Technology demonstration	50%	Very High 1900x-560x demand	2025 to 2030	sunfire, SAF+ CONSORTIUM	90%	*[highest cost SAF]* 6x

1 TRL stands for technology readiness level, and ranges from low 1: basic technology research all the way to high 9: system test, launch and operations.
2 AtJ feedstock availability reflects global view. Could be lower in EU with restrictions on use of crop-based or food-based feedstocks; e.g. alcohol from corn.
Sources: PA Consulting analysis; IATA; ATAG Waypoint 2050; US DOE.

Great — Not great

Comparison of SAF pathways across drivers of supply and demand

3. Typical project life cycle and phases / types of funding and incentives

The project life cycle for sustainable aviation fuels (SAF) production and uptake typically involves the following key stages:

1. Research and Development (R&D): identifying and developing technologies to produce SAF
2. Pilot Plant Demonstration to commercial scale-up: after production processes are validated in small-scale pilot plants, constructing larger commercial-scale plants. Investments to ramp up production capacity, optimize operations, and achieve economies of scale
3. Certification and Compliance: demonstrating SAF's environmental sustainability, safety, and compatibility with aircraft engines so the SAF output meets international standards and regulatory requirements for aviation fuel.
4. Market Deployment and Uptake: SAF enters the market through partnerships with airlines, fuel suppliers, and airports. Initiatives include blending SAF with conventional jet fuel, establishing supply chains, and promoting SAF adoption among airlines and consumers.
5. Monitoring and Optimization: continuous monitoring of SAF production processes, environmental impacts, and performance to check compliance and certification as well as innovate to optimize.

The sources of funding also typically vary, as the magnitude of the funds, the risk profile and the pay-back periods evolve. The earlier stages, often starting with R&D, can qualify for partial or complete government, public sector or private and/or philanthropy funding. Venture capital typically supports early-stage, highest risk phases of development, before Private Equity typically joins. In order to meet considerably stricter risk requirements, corporate and commercial lenders and infrastructure funds have to date had limited forays into SAF project investments, although this is certainly changing, and the last two years have seen not only growing interest but actual investment from a number of long-term investors, such as DIF, OTPP and CIP.

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4. SAF Policy landscape in Europe

The most direct policy measure in Europe for SAF scale-up is the emergence of binding mandates. In addition, there are incentives available, both at the EU and at national level. And on the other side of the scale the EU Emission Trading System and the proposed Energy Taxation Directive aim to increase the cost of not decarbonising, making SAF a more attractive option.

a. SAF blending mandates

The EU Fit for 55 package, including ReFuelEU Aviation initiative, is an integral component of the European Union's strategy to reduce greenhouse gas emissions and promote SAF as a key pillar of decarbonising air transport[2].

- **EU Fit for 55** is a comprehensive legislative package that aims to reduce the EU's greenhouse gas emissions by 55% by 2030 compared to 1990 levels. It includes a wide array of measures targeting all sectors, including aviation. Within this framework, proposals such as the ReFuelEU Aviation initiative aims to enhance the production and uptake of SAFs.

- **The ReFuelEU Aviation initiative** focuses on increasing the use of SAFs in the aviation sector by mandating SAF blending requirements for fuel suppliers at EU airports, starting with a minimum of 2% SAF by 2025, 6% in 2030 (1.2% must be syn fuels) and increasing fast to 70% in 2050 (half of it, 35% must be syn fuels).

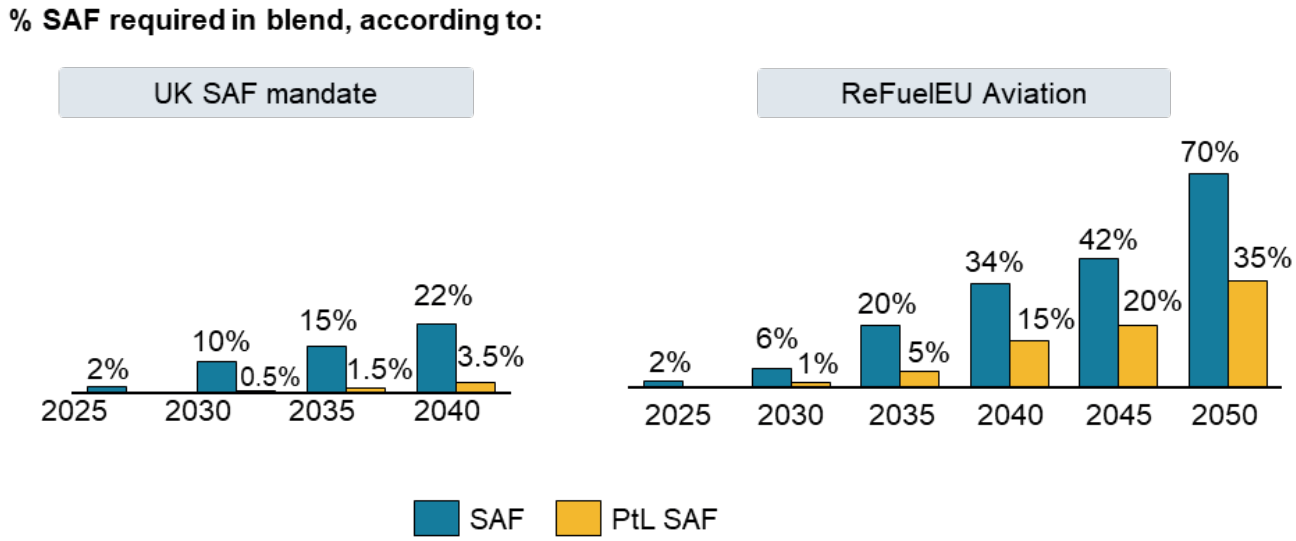
- The scope of eligible sustainable aviation fuels and synthetic aviation fuels includes certified biofuels, renewable fuels of non-biological origin (including renewable hydrogen) and recycled carbon aviation fuels complying with the Renewable Energy Directive (RED) sustainability and emissions saving criteria, up to a maximum of 70% with the exception of biofuels from food and feed crops, as well as low-carbon aviation fuels (including low-carbon hydrogen), which can be used to reach the minimum shares in the respective part of the regulation.

The mandate will be implemented at the EU level, superseding national targets and setting out harmonised minimum obligations for all flights departing from EU airports. However, Member States are expected to propose their own penalties as enforcement mechanism for fuel suppliers and airlines. The penalties are expected to be significant, ranging from €1000 - €6000 per tonne of fuel for the advanced bio and synthetic fuel mandates. To prevent tankering practices, the provisions require aircraft operators to ensure that the yearly quantity of fuel uplifted at a given EU airport is at least 90% of the yearly aviation fuel required.

Lastly, the initiative includes the creation of a Sustainable Aviation Fund from 2023 to 2050 to accelerate the decarbonisation of the aviation sector and support investment in sustainable aviation fuels, innovative aircraft propulsion technologies, or research for new engines. The fund would be topped up by penalties generated by the enforcement of these rules.

Although outside the EU, it is worth highlighting that the United Kingdom has proposed a very similar approach to the EU in terms of developing the government policy on SAF around mandating supply. The UK SAF Mandate, announced in April 2024, takes effect from 2025, setting minimum blend rates for all flights leaving UK airports. Unlike the EU, it includes a cap on HEFA-based SAF and, similar to the EU, it introduces a sub-mandate for Power-to-Liquids (PtL) SAF in 2028.

[2] European Commission (October 2023) Press Release on ReFuelEU, available at: https://www.consilium.europa.eu/en/press/press-releases/2023/10/09/refueleu-aviation-initiative-council-adopts-new-law-to-decarbonise-the-aviation-sector/



Mandated SAF blend rates in the United Kingdom and the Europe

b. Incentives for producers

The EU policies on SAF are mostly composed of legislation that ensures ever-increasing SAF usage, setting punitive consequences for failures to supply SAF for use at EU airports above a certain size[3]. However, it would be an oversimplification to state that the EU policy suite is mostly 'sticks'.

One significant incentive (or 'carrot', following the above terminology) available for producers come from the EU SAF Innovation Fund, part of the broader EU Innovation Fund. This is a major financial mechanism dedicated to supporting innovative technologies that can significantly reduce greenhouse gas emissions in the aviation sector through sustainable aviation fuels, by providing a projected total of €25 billion funds by 2030.

Eligibility requirements include demonstrating a high potential for cost-effective greenhouse gas reduction, technological innovation, scalability, and market readiness. The fund supports (i) large-scale projects with grants covering up to 60% of the additional costs of innovative technologies compared to conventional solutions; and (ii) smaller-scale projects through a separate stream within the same fund, to ensure a broad range of innovative ideas can be nurtured and brought to market, accelerating the EU's transition to a sustainable aviation industry.

[3] Higher than 800 000 passengers or where the freight traffic was higher than 100 000 tonnes in the previous reporting period, and which is not situated in an outermost region, as listed in Article 349 TFEU.

c. Allowances and the Emissions Trading Scheme

At a more general level, the EU also has a range of policies in place which limit the overall carbon emissions from aviation, serving to increase the cost of carbon, and including a SAF specific financial incentive. These, taken together, are intended to close the 'green premium' from the perspective of SAF buyers (i.e. the airlines) and thus contribute to the overall policy landscape for investment in SAF production.

EU Emissions Trading System (ETS):

The EU ETS works on the principle of 'cap-and-trade'. It sets an absolute limit or 'cap' on the total amount of certain greenhouse gases that can be emitted each year by the entities covered by the system. The total number of aviation allowances in the ETS will be capped at current levels and be reduced annually by a linear reduction factor of 4.2%. Free allowances allocated to aircraft operators will be phased out by 2026.

All airlines operating in Europe, European and non-European alike, are required to monitor, report and verify their emissions and to surrender allowances against the emissions. Flights within the European Economic Area (EEA) and to Switzerland and the UK, will continue to be covered by the EU ETS.

Twenty million free EU ETS allowances will be available to aircraft operators to mitigate the cost gap of SAF from 2024 to 2030. Allowances can be used to cover between 50% - 100% of the cost difference between fossil jet fuel and SAF on all routes covered by the ETS, depending upon the fuel pathway used (e.g., 95% synthetic SAF, 70% advanced biofuels, and 50% for all other SAFs covered under ReFuelEU).

It should be noted that the ETS is aligned to ICAO's CORSIA regime. From 2027 onwards, it will be mandatory to be part of CORSIA for all European countries. The EU ETS Directive will apply CORSIA to EU-based airlines' emissions from flights to and from countries outside the EEA. When emissions from flights outside the EEA reach levels above 2019 they will have to be offset with corresponding CORSIA-eligible carbon credits. This alignment is due to be reviewed in coming years and scope remains for EU ETS to be broadened to flights to/from non-EU points; however, this remains a contentious issue at the international level that is unresolved at present.

Energy Taxation Directive (ETD)

The ETD is a legislative framework first introduced in 2003 that sets the minimum rates of taxation for energy products and electricity within the EU. Objectives are to avoid significant tax level differences among Member States, and promote energy efficiency and the use of cleaner energy sources.
Fuel for passenger flights has been tax-exempt.

Since July 2021, there has been a proposal to revise the ETD to better align with the 2050 climate neutrality target, which includes introducing excise duty rate for intra-EU passenger flights as well with lowest min tax rates for SAFs compared to highest min rates for conventional jet fuel[4]. Although agreement on the text requires further work and a clear target deadline for the revised ETD is not in sight[5]; these revisions would significantly improve the economics of SAF over conventional fuels in Europe if they are implemented in the future.

d. Areas of remaining uncertainty

The EU policies on SAF continue to evolve and there are a number of areas of uncertainty. One such area is the flexibility mechanism within the ReFuelEU Aviation initiative. This mechanism allows for some flexibility in how fuel suppliers meet their SAF blending obligations for the first ten years of the mandate. Were it not in place, every airport with over 800 thousand annual passengers would require that its fuel supply included 2% SAF, which would be an implausible expectation. Instead, eligible aviation fuel suppliers are able to demonstrate that they have supplied a 2% blend across their eligible EU airports. The Commission continues to engage and consult on the flexibility mechanism and is expected to issue further guidance during 2024.

Another significant area of uncertainty is the enforcement of penalties for non-compliance with SAF mandates. The current policies outline that fuel suppliers failing to meet blending targets will face financial penalties, but the specifics remain to be fully defined and their level and enforcement is delegated to individual member states. There are some questions and concerns about how penalties will be harmonized across different EU member states to maintain a level playing field. Crucially, from an investment point of view, if the penalties for non-compliance are deemed to be insufficiently high or enforced, it presents a significant demand-side risk to SAF projects, whereby buyers may simply choose to pay the penalties instead of committing to long term, increasing offtakes from SAF projects.

[4] Proposed changes under consideration include: "lowest min rate of €0.15/GJ for advanced sustainable biofuels, e-fuels and biogas (a rate significantly below the reference rate as electricity and these fuels support EU's clean energy transition)" and "highest min rate of €10.75/GJ for conventional fossil fuels when used as motor fuel". Pleasure flights are already fully taxed under the current rules, but the proposed changes extend taxation to business flights and passenger flights intra-EU and sets a differential among SAFs versus kerosene. See the "Revision of the ETD Questions and Answers" on: https://ec.europa.eu/commission/presscorner/api/files/document/print/en/qanda_21_3662/QANDA_21_3662_EN.pdf

[5] In June 2024, the Council reviewed again of the file's state-of-play. The Belgian presidency of the Council had put forward several compromise texts during the first half of 2024. These compromise texts contained prolonged transitional periods and the possibility for Member States to provide total or partial exemptions for certain sectors and services. However, the Belgian presidency concluded that countries' positions remained nevertheless divergent, requiring further work to reach a balanced agreement. See: https://www.europarl.europa.eu/legislative-train/spotlight-JD22/file-revision-of-the-energy-taxation-directive

e. Key points for investors

The mandates being introduced in the EU and UK are providing assurance that demand for SAF will be a requirement, which is a key foundational element of demand certainty. Although policy u-turns or revisions cannot be ruled out, the legal nature and Europe-wide scale of the policies provide considerable reassurance that these policies will not be cancelled or altered lightly.

At the same time, volume certainty does still leave open the question of how SAF is to be priced and how investments will recover or become profitable.

Clear production incentives or revenue guarantees for existing and new fuel producers would help overcome revenue uncertainty as a key barrier to investment and:

- provide assurance to suppliers that their first few facilities can become profitable
- allow suppliers to use profits and investment to move to commercial plants with improved production costs
- provide assurance to investors that there is continued growth across the SAF space

The UK government at the end of June finished consulting on a range of possible revenue-certainty mechanisms, including a guaranteed buyout price, which would come into effect in 2027, providing some further reassurance to investors. However, this is an area rapidly evolving, and may yet fail to achieve political support in a form that is beneficial to SAF investors.

5. SAF Policy landscape in the United States

We present the SAF policy landscape in the United States in terms of the federal initiatives, state-level differences and incentives, voluntary airline commitments, and the key points of importance for investors. US SAF incentives are aimed at the production side, rather than the demand side – essentially there is a "carrot", but no "stick" yet, as there are no usage mandates or mandatory targets.

The US does not have legislated mandates to use SAF, but heavily incentivizes production both at the federal-level (through the Renewable Fuel Standard and tax-credits) and at the state-level through incentives. On the demand side, jurisdictions with active low-carbon fuel policies and incentives such as California see the highest activity.

a. Federal-level initiatives

The Renewable Fuel Standard (RFS) and Renewable Identification Number (RIN) trading

Through the RFS program, SAF is eligible for RINs that can be traded and sold, providing an economic incentive for SAF production. Fuels with more energy content generate more RINs, where baseline for energy content comparison is ethanol, known as a fuel's 'equivalence value' (eq val).

The RFS is a federal regulatory program promoting the production and use of renewable fuels, such as SAF, in the transport sector.

- Established under the Energy Policy Act of 2005 and expanded by the Energy Independence and Security Act of 2007.

- Overseen by the Environmental Protection Agency (EPA) who ensure compliance and assigns values and categories.

To track the RFS program, the EPA assigns each gallon of renewable fuel produced a Renewable Identification Number (RIN).

- It categorises fuels into four nested groups, each requiring different levels of greenhouse gas reduction: conventional biofuels (D6 RINs), non-cellulosic advanced biofuels (D5 RINs), biomass-based diesel (D4 RINs) and cellulosic biofuels (D3 and D7 RINs). Cellulosic is the most stringent category at >60% GHG reduction.
    - SAF typically qualifies for D4 RINs as a biomass-based fuel, and can qualify for other RINs, depending on feedstock.

- Biofuels are put to an ethanol gallon-equivalent basis: one gallon of ethanol generates 1.0 D6 RIN, but more energy-dense fuels can generate more RINs; this comparison is known as a fuel's "equivalence value". A higher equivalence value means more RINs are generated.
    - For example, SAF has an eq val of 1.6-1.7 whereas biodiesel has 1.5, which gives economic advantages to SAF producers over biodiesel (contested by biodiesel producers).

The RFS program sets annual renewable volume obligations (RVOs) that specify the minimum volume of renewable fuels, such as ethanol, biodiesel, and advanced biofuels, to be blended into the transportation fuel supply.

In 2023, the RFS statute called for the consumption of c.21 billion gallons of renewable fuels, across the four nested categories.

The Inflation Reduction Act (IRA) tax credits

The Inflation Reduction Act (IRA) also offers tax-incentives for SAF production, where the value is based off the carbon intensity of the fuel. This two-phase tax credit is broken into two timelines:

- **Phase 1 (2023-2024):** establishes a new per-gallon incentive for SAF, expanding the Biomass-Based Diesel Blenders Tax Credit. Qualifying fuel can collect $1.25-per-gallon SAF credit if GHG emissions are reduced by at least 50% compared with petroleum-based jet.

- **Phase 2 (2025-2027):** enhanced tax credit to make SAF eligible for the Clean Fuel Production Credit (CFPC). The CFPC sets a baseline emissions factor for SAF at 50kg CO_2/MMBtu. The base credit is $1.75-per-gallon SAF, with an additional credit accounting for the full lifecycle GHG emissions of the fuel.

For both phases, the credit is earned by the producer of the qualifying fuel rather than the blender, and in addition to the 50% GHG reduction threshold or baseline emissions factor, eligible SAF must:

- Be produced in the US.
- Meet requirements of ASTM International Standard D7566 or Fischer-Tropsch (FT) provisions.
- Be produced from eligible biomass material (defined to mean any organic material other than (a) oil and natural gas, and (b) coal, including lignite, or any product thereof).

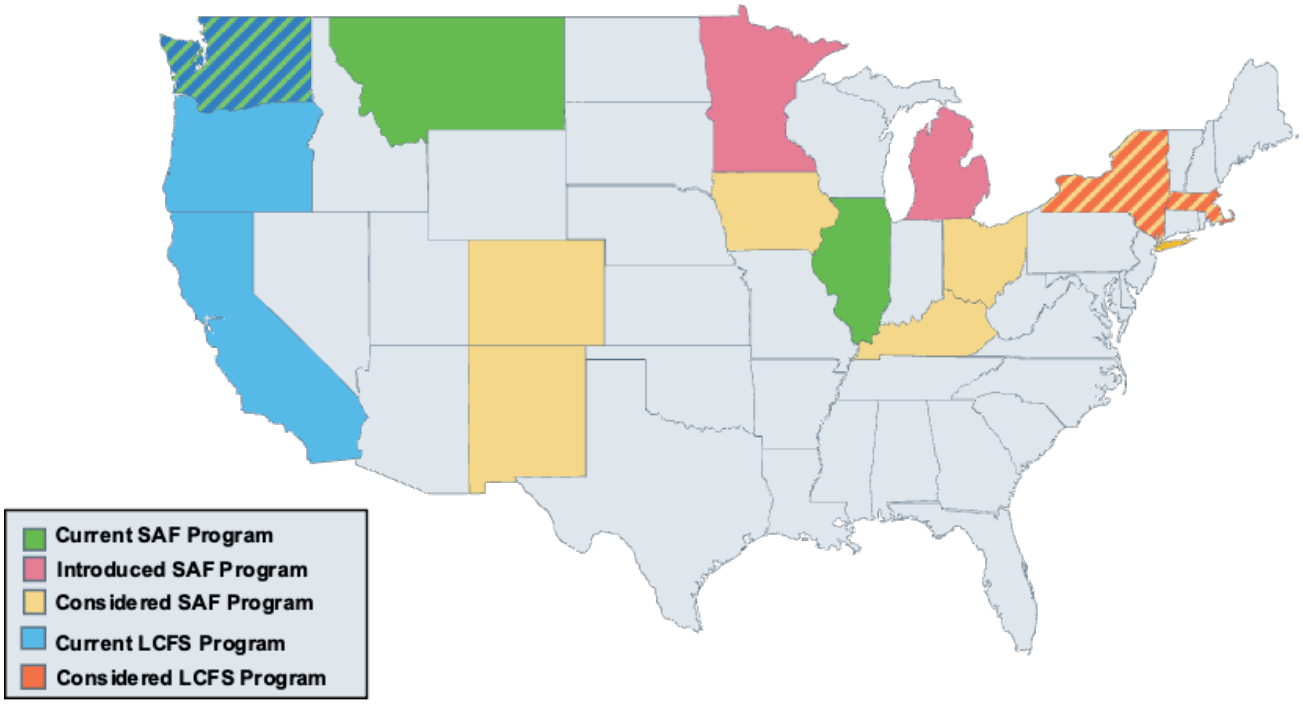
Importantly for SAF investors, there is currently little certainty around what will happen to the IRA support mechanisms after 2027, and with the US general elections in November 2024, clarity is unlikely before 2025.

b. State-level initiatives

In addition to the federal policies described above, there is a range of state-level policies emerging or in place, which means SAF production and investment conditions vary significantly by location. Importantly, it is at the point of blending that most state-level policies take effect, not production, therefore producers and investors need to consider not only the typical feedstock, technology and local policies, but also the route to market and the economics of blending and offtaking SAF.

Low Carbon Fuel Standard (LCFS)
Different states have implemented low-carbon or clean-fuel standards that offer credits to promote the import and utilization of SAF within their borders. These LCFS programs provide markets for SAF procurement, and it is expected that SAF will continue being directed into state markets where LCFS-type programs and financial incentives exist (California, Oregon, and Washington). There are several states considering implementing similar LCFS-type programs including Minnesota, New York, New Mexico, and Colorado.

Tax incentives
Several states across the country have SAF tax incentives that encourage state-specific use and production of SAF. At the time of this report, four states have SAF specific tax incentives (Illinois, Montana, Washington and Minnesota). Other states with LCFS programs have made SAF an eligible fuel for LCFS credits (California). Oregon considers SAF importers and producers to voluntarily meet state targets of carbon intensity reduction by 2035, and Washington has both a SAF-specific tax incentive and an LCFS program. Kentucky introduced a SAF incentive in 2022 (yet to be passed), and Colorado attempted to advance a SAF incentive, but the measure failed in 2023.



US state-level SAF incentives

c. Government loan guarantees and grants

The U.S. Department of Energy (DOE) provides loan guarantees and grants to support the development and commercialisation of SAFs. These financial mechanisms help to de-risk investment in SAF projects and accelerate the deployment of innovative technologies. They help secure financing for large-scale production facilities and infrastructure needed to produce SAFs.

Loan guarantees are administered by DOE's Loan Programs Office (LPO). Eligible projects include advanced biofuel technologies, renewable energy production, and other innovative processes that contribute to the sustainability of aviation fuels. Applicants undergo a rigorous review process, including technical, financial, and environmental assessments. Selection depends on demonstrating a significant reduction in greenhouse gas emissions compared to traditional fossil fuels; and potential for commercial viability and scalability. Successful applicants receive guarantees that cover a significant portion of the loan, making it easier to obtain financing from private lenders.

SAF Grants provide direct funding support for research, development, and demonstration projects related to SAFs; and administered by DOE's Office of Energy Efficiency and Renewable Energy (EERE). Grants can be awarded to academic institutions, research organizations, private companies, and consortia. To be eligible, projects must focus on advancing the state of SAF technologies, including feedstock development, conversion processes, and lifecycle analysis. They should also align with the DOE's strategic goals for reducing carbon emissions and enhancing energy security. Proposals are evaluated based on criteria such as innovation, technical merit, feasibility, and alignment with DOE priorities.

d. Airline commitments

Without legislated mandates and in the absence of a carbon market (similar to the situation in Europe), the 'SAF premium' will be driven by airlines' willingness-to-pay for decarbonizing their emissions from flights. GREET and CORSIA carbon offset prices can offer a guidance, but this willingness-to-pay will be ultimately negotiated with the airlines bilaterally. Levelized production costs are expected to create the "floor" for offtake pricing with incentives allowing for competition between the various SAF production pathways.

In 2021, the White House announced the SAF Grand Challenge, which is a program of entirely voluntary blending targets of 10% by 2030, and 34 billion gallons of SAF produced (approximately 100% of jet demand) by 2050. Nearly all major American airlines have committed to the goals outlined in the Grand Challenge, including American, Delta, United, Southwest, JetBlue, FedEx, and UPS.

Offtake in the program is entirely voluntary, there is no financial incentive for airlines to participate in the program. The incentive for airlines lies in being able to meet emissions reduction and voluntary sustainability goals. There is a financial incentive for producers of SAF, however, who are able to claim both federal and state credits, subject to qualification criteria, as discussed above.

This approach is quite different from the EU approach in which there are obligations that fuel users must meet – US SAF programs are entirely voluntary, with incentives as rewards, but no penalties for non-adoption.

e. Key points for investors

US SAF incentives are aimed at the production side, rather than the demand side – focused on making the development and production of SAF economically sustainable for private sector investors. By lowering the effective cost of production, in some cases to levels comparable to fossil-based, conventional jet fuel, demand has been stimulated, and a substantial share of global SAF today is understood to be uplifted in the US, even if it is not produced there. When producers can strike contracts that also work for airlines, the market requires little further interference.

However, the voluntary nature of incentives can lead to variability in SAF uptake and may not guarantee long-term, consistent growth without additional regulatory measures. And in contrast to the EU, the degree of political risk may be considered greater, given the combination of both federal and state-level risks. One key question at the federal level is whether and for how long the IRA policies will be extended or renewed beyond 2027, which in the context of SAF production facilities is considered an insufficient time horizon.

6. Summary and conclusions

The EU and the US have adopted visibly different approaches to support the scale-up of sustainable aviation fuels.

The EU's approach is characterized by regulatory mandates and strategic funding mechanisms. The ReFuelEU Aviation initiative sets mandatory blending targets for SAF, starting at 2% by 2025 and increasing to 70% by 2050. Additionally, the EU Innovation Fund provides substantial financial support for innovative SAF projects, funded by revenues from the EU Emissions Trading System (ETS). This dual approach aims to create a clear market demand for SAF while also investing in the development and deployment of SAF technologies.

The US approach primarily relies on incentive-based policies targeting production ('all carrots, no sticks'). The Renewable Fuel Standard (RFS) mandates the blending of renewable fuels with conventional fuels and provides Renewable Identification Numbers (RINs) as tradable credits to incentivize compliance. Additionally, tax credits and grants are available for SAF producers and projects, while government loans and loan guarantees can provide further support. Recent legislative actions, such as the Sustainable Skies Act, further incentivize SAF production through federal tax credits specifically for SAF through the Blender's Tax Credit (BTC). Additionally, various states offer their own incentives and tax credits for SAF production, which can vary significantly.

Effectiveness of the two distinct policy approaches will become clearer towards 2030, as we approach the first milestones for targets of both policies.

The EU's regulatory-driven approach provides a strong and clear framework for SAF adoption, ensuring steady growth in usage through mandated targets, as part of wider EU carbon policies through the use of cap-and-trade EU ETS. However, the effectiveness of the policies will depend on the ability to enforce compliance, availability of supply and the availability of funding to stimulate the necessary technological advancements and production scale-up.

The incentive-based approach in the USA has successfully driven SAF innovation, as evidenced by increasing production volumes and a growing number of SAF projects. However, the voluntary nature of incentives can lead to variability in SAF uptake and may not guarantee long-term, consistent growth without additional regulatory measures.

Overall, the EU's approach ensures steady market integration and the USA's incentivises fostering early innovation and production capacity. Comparing SAF use values, both regions are on an upward trajectory, but very much at the base of a mountain to climb. It will take consistent, supportive policies in a growing number of markets, ideally in a consistent way to minimise carbon leakage and market distortion, to achieve the scale-up necessary as part of wider energy transition in aviation.

4. Two perspectives on what makes sustainable aviation investment compelling (or still unattractive)

Lukas Kaestner & Niklas Lund

Lukas Kaestner is co-founder and CCO of the Sustainable Aero Lab, the world's largest program dedicated to accelerating startups in sustainable aviation. In addition, Lukas serves as CDO of the ZAL Center for Applied Aeronautical Research in Hamburg.

Niklas Lund is the CEO of Rockton, Stockholm. He has 30 years' experience in aviation finance. Rockton has pivoted its operation to support the sustainable transformation for the aviation industry.

Getting to know Rockton

Since its inception, Rockton has arranged, managed and executed more than 40 commercial aircraft investments. But today, your firm exclusively focuses on sustainable and climate-change mitigating aviation investments and assets. What kind of products does that cover and how does your commercial aircraft specialization shape your investment approach?

Niklas Lund, Rockton CEO: We're actually looking at the whole universe of decarbonization or greenhouse gas (GHG) reductions applicable to aviation. That obviously includes new propulsion, SAF both on potential new technology that could lower the production cost, but also production facilities, and carbon capture both in terms of technology and production facilities both for storage and for feedstock for e-SAF. We're also looking at ground infrastructure, that could be existing infrastructure, for example electrifying ground equipment, buses, baggage carts, you name it... but also new infrastructure that's needed for new propulsion, like charging infrastructure.

We're also looking at contrail identification and avoidance. And then we have a focus on what we call ‚operational support services'. That's usually software solutions, for airlines primarily, whereby they can become more efficient and thus burn less fuel and emit less GHG. And then we have another leg, which we call climate change adaption, where we're looking at aviation assets that don't need to be sustainable in themselves, but their operation is. An example would be aerial firefighters, as wildfires emit a lot of carbon dioxide and combatting them hopefully saves life and property but could also be environmental surveillance drones and the like. What we're not covering are incremental improvements of current technology aircraft, which of course can add efficiencies, but that seems to be the domain of the larger incumbent OEMs and their suppliers. That's their home turf, so to speak.

Getting to know Sustainable Aero Lab

Through your role at Germany's Center of Applied Aeronautical Research (ZAL) you co-founded Sustainable Aero Lab, which since inception in early 2021 has supported over 80 startups. What kind of products and services do those startups comprise and how does Sustainable Aero Lab propel them in finding the right investment?

Lukas Kaestner, co-founder and Chief Commercial Officer of the Sustainable Aero Lab:
Sustainable Aero Lab is the leading program for start-ups that deal with sustainable aviation. And we bring together companies with mentors from aviation, from related industries, from venture capital... in very intense feedback sessions every two to three months. We started out as a lockdown project in the Covid-19 Pandemic and our first session was in early 2021. So far, we have worked with over 80 companies from around the world. Two weeks ago, we had our first in-person session in the US at Stanford University with 10 start-ups. We also look at the whole range of sustainability technologies, so anything that lowers the footprint of the aviation industry or air travel is relevant to us. That can be SAF, hydrogen, novel designs... but it that can also be operations, especially on the software side, where we also have a lot of potential still for gaining efficiency.

We currently work, among others, with Breakthrough Energy founded by Bill Gates, with Embraer on the OEM side, JetBlue Ventures, and the World Economic Forum (WEF). We are not only trying to do a mentorship program, but we're also trying to do some think-tank work to push the entire industry into one direction where we can discuss the right issues about sustainability down to the core of what do we really need.

We basically want to build a platform where everybody can come together to discuss sustainable aviation at eye-level. The ZAL, the Centre of Applied Aeronautical Research which is an innovation campus here in Hamburg, is not directly linked to Sustainable Aero Lab, but it's indirectly linked. This means we give the companies that are interested access to do research and build demonstrators, for example, on the ground here, and work with our experts in Hamburg so if they want to do testing on-site we have the facilities and the networks.

Their perspectives

The average avid traveler has probably never heard of a hydrogen aircraft and perhaps only vaguely of a battery-powered one. And yet, ask them if they have heard of „flying taxis" and they probably have. Does this disparity broadly extend to investors?

Lukas: I would say maybe a little. I think investors have a better and deeper perspective on the market than the average passenger. But nevertheless, if you look at the investments that we've seen in the aviation industry in the past few years, you can definitely say that e-VTOLs sell and other sustainability technologies still have a challenge selling their storyline. I think creating a storyline that appeals both to investors and to the passengers is one of the major challenges that we will need to answer, not only as the aviation industry, but how do you make climate-friendly or climate change-mitigating technologies more appealing to investors, to the public, to policy makers...? Airline product offerings have really developed over the past 10 years. When you look at the different classes that you have: business class, premium economy class, economy class... Those are very accessible to the passenger in terms of ‚what do I get, what's the value proposition'. But if you look at the sustainability aspect, you don't have this implemented into the product yet. Sustainability is not really visible to the passenger yet. In some details, it is visible now. For example, within the Lufthansa Group, if you book a flight, you can choose a Green Fare, you pay a premium and then it says your percentage of SAF. But nobody, I would say, from the general public knows what SAF is, and the rest is compensation projects. It's basically a feel-good click button to for the passengers who experience flight shaming during booking. But this is not where we need to be. We need to be more vocal and more specific on how we can be part of the solution.

Niklas: I think the awareness of e-VTOLs is not huge, there's probably more in the US than in Europe. But of course, from an investor standpoint it doesn't help that public shares have tanked over time. A lot of those companies are facing huge problems. Some will probably weather it, but others have, especially finance, problems. We also have to admit that, for an investor, aviation is a niche, and you compete with everything else. It's interesting what Lukas took up there. I was thinking also about politicians and therefore policymakers. For example, we have the Bromma city airport here in Stockholm which is very well suited to new propulsion technologies. But the Green Party just wants to close it down. You would think that they would actually embrace new sustainable travel, but they take the view that anything with aviation is just a red flag. So, there is some work we have to do, in general, to actually be able to communicate with policymakers that there is a transformation happening and you should actually embrace it.

Lukas: This is an excellent point by Niklas. There's a very big learning from the Covid-19 Pandemic for this industry here: that the way out is through innovation, and only through embracing innovation we will find the solution. As we did with the vaccine that got us out of the Covid-19 Pandemic, it wouldn't have helped us if we would have closed down bars and restaurants forever. But it was only through innovation. And I think this is the learning we need to take away into other challenges for our entire society in the future.

E-VTOLs ("flying taxis") were a coveted up-and-coming asset class by tech investors in recent years, but the tide on their popularity has begun to change as some firms went out of business and those still around face regulatory and certification challenges. Have these experiences negatively impacted the investability of clean propulsion firms in the fixed-wing aircraft space?

Niklas: From my end, obviously it's not helping. If we look at the alternatives to e-VTOLs, like fixed-wing electric or hybrid-electric conventional take-off and landing (e-CTOLs) and similar, from an investment perspective it is a bit challenging because there's a lot of development cost that has to go into a project and it also takes plenty of time until you have proof of concept. If you compare that with other types of investments outside of aviation, you may have much shorter timelines so you can actually invest smaller amounts in the beginning. If it works, you can throw more money at it. If it doesn't work, you just walk away. But here, if you're going to develop a new aircraft type, it takes plenty of time, plenty of challenges, and the proof of concept comes very late. It's not perfect for the venture capital market.

That's the main challenge for those types of investments. And currently it's quite a tough market to raise private capital but that situation will likely change over time. If we look at CTOL there's significant lower market risk. If you have a reasonably sized aircraft with a reasonable payload and range, it can actually be put into existing networks. So that's one part of the risk package that is less obvious than it maybe is for e-VTOLs, which require substantial new ground infrastructure and where the use cases vary.

Lukas: I personally think that, when we look at the e-VTOL market, the big challenge is still to come. Right now, everybody has placed their bets, so to speak. But e-VTOL companies, even though their performance in the past few months and years has been mediocre at best, are still out there. We can still think of a scenario where we will see some consolidation between the players, where some companies will actually exit the field and we will have to probably brace for a situation then where, at least for venture capital investment, everybody will have a hangover feeling when they look at aviation and go: ‚this industry is not for venture capital' - because it is tough and certification, a Niklas mentioned, is a big subject that's very expensive and very high risk. The main challenge for us in the aviation industry will be to keep up the spirit of investors and say ‚well, it will be different for some areas, when you look at sustainability technologies and aviation.' Niklas has made a very good point here. When you look at commercial aviation, you don't need the 'proof of concept' because the proof of concept is there: there are over 200,000 commercial flights per day in the world.

One could argue that it was just not tech investors being new to investing in an aircraft OEM, but so is everyone else! Commercial aircraft manufacturing has for decades been controlled by a handful of firms, including a state-supported duopoly at the larger end of the market. Is new aircraft design and certification just too complicated for virtually all investors to feel confident about where they should invest?

Lukas: I would not say so because if you look at even established markets, you have always seen, especially in transformation processes, new players emerge. And the last industry where we've seen this happening was automotive. I think we can all agree that companies like Tesla have definitely changed the market dynamics of that industry in the past 15 years. If Tesla would've not shown up, probably the strategy of Volkswagen or BMW would be different today. So, there is room. What one has to take into account is that aviation is an industry driven not only by revenue but also by regulation, especially certification. And that makes it very expensive and very risky compared to other industries. It benefits large players. If you look at OEMs, establishing a new OEM is only possible if you win sustainable support from policy measures or from politics. An alternative to this would be if you can connect the dots by getting established players to work with you on your technology. For example, bringing in somebody like Embraer or other players like SAP who have been in the commercial business for the past few decades. So, if you can bring in people who have the experience already then you don't need to build up everything from scratch.

Niklas: I agree. I think Lukas used a very good example of Tesla and EV's. But as Lukas pointed out, investing in a new-technology aircraft OEM takes a longer time and costs a lot of money, which may not be perfect for most investors. But also, if you look at the benefits side, if you succeed in a commercial market there is really nice upside. The situation with the existing OEMs, from an investor standpoint, offers you very good trade-sale opportunities. Because if you succeed in creating a new sustainable and viable aviation asset, that might be something that the OEMs would really like to acquire in the future. But as we pointed out several times in terms of the investment profile: investing in upstart OEMs is not perfect for most investors. Because of the capital requirements and the time it takes. But there is a big golden pot at the end if you succeed, there's no doubt about that.

Let's turn to SAF. The less advanced pathways of SAF are commercially proven at scale and have certainty of demand as part of incoming policies like the EU SAF mandates. The more advanced pathways should also have a high certainty of demand as long as policies remain consistent in the long-term. All help decarbonize flying on a lifecycle emissions basis. Should investors looking to put money to work in the decarbonization of aviation look at SAF more than other options? How come that only 1/3 of global VC money in aviation's decarbonization is directed at SAF vs electric, hydrogen et al?

Niklas: If we start with the first question: I'm not sure they should invest in SAF more than other options, but they should definitely invest in SAF because there's very strong demand, and as you say, it's supported by policy. I think we'll see more and more investors coming into SAF undoubtedly, what lacks is technology and market maturity. We only have HEFA SAF which can be deemed mature and we will soon have alcohol-to-jet (AtJ) SAF. We see that mainly large airlines are investing now more and more, and the reason why they invest is to procure SAF. While for an investor the intention is to have an attractive value proposition from what they're providing capital to. Hopefully we can have public money coming in and helping with this maturity, because that's what's needed. The more it matures, and more it's proven, market acceptance increases, long-term offtake contracts will be entered into, the more capital will come to it.

Then to the second question, well I would say there's two SAF investment types. One is to invest in the technology. There, it seems like VC could be more active because that's more their traditional type of investments. However, if we look at production facilities, that's more the traditional infrastructure investment opportunity. Traditional infrastructure investors are getting engaged, but at a lower scale at the moment. But again, what's needed is maturity of the technology, resolved long-term feedstock issues and all the offtakes. Once that comes, more capital will come into it, no doubt about that.

Lukas: I have to underline what Niklas said here. Maturity is the big aspect when discussing SAF and not all SAF is equal because it really depends on the feedstock. If we talk SAF today, it's basically the HEFA process, which means using oils and fats, and those feedstocks are limited. You cannot have every aircraft in the sky fly with a blend of HEFA SAF. We need different ways to create SAF and there are different maturity levels across other SAF production pathways. This is not only a technological question, but it's also a policy question. If you look at the US, for example, they are much more open to SAF coming from agricultural origin. If you look at Europe, you have a high population density where it quickly becomes an ethical discussion. The European discussion has circled around power-to-liquid (PtL) SAF a lot more, or so-called e-Fuels. This is great in theory, but again, this is the pathway with the lowest maturity. We don't have a PtL SAF plant that can produce at industrialized scale today, so as long as you don't have this maturity you will not see big investments.

The other challenge is that even though we have the quotas now in the European Union with ReFuelEU Aviation we don't see a lot of investment from the big oil and gas companies yet, because for them there is also a lot of risk into putting money down. And right now, Shell and BP and all the other incumbents are making good revenue with the current way of producing fossil fuels. They will not do things voluntarily, especially if it immediately impacts their revenue model. I think we will see a lot of pressure building up over the next few years in terms of politics, in terms of public opinion. But again, we have to also look at what is the storyline for innovation. I'm hoping that we can really see at some point a breakthrough in maturity of one technology. That would really be the ideal case.

Let's not forget about carbon capture. Lately we heard someone say that SAF will ultimately be skipped technologically (not sustainable, too expensive) and replaced by CC (easier to scale, no dependence on raw materials, „only" on green energy). What is the interest of investors in carbon capture? What is needed to attract capital?

Lukas: It's a difficult question because here, again similar to what we discussed around SAF, we still have the aspect of maturity: How could it potentially scale? What could be the potential impact of this technology? I don't think there is a clear answer to this yet. And then if we want to discuss carbon capture within aviation, the other aspect that we need to look at is how relevant aviation is to the carbon capture segment? If carbon capture really develops and scales, are we the only industry that can really connect to this segment? Or are there many other ways of using this technology where maybe somebody else, some other industry with a much higher impact, with much more revenue will come and basically clear the whole market. And then aviation again, is left as the niche as Niklas said before, and it doesn't really have access to the market because it's too small.

Niklas: As Lukas pointed out, carbon capture is universal. It's not specific for aviation. There are plants around the world. I think most of them are actually used for extraction of more oil, unfortunately. But the issue today is that is quite expensive, around $500 per tonne if you use Direct Air Capture, while you have the EU ETS is trading about €70 per tonne. What of course aviation has to do is to see whether it can get hold of carbon capture technology for PtL SAF. That could be biogenic, which is probably the lower-hanging fruit at least initially, and over time Direct Air Capture (DAC) which is the least mature one, but probably also the one that has most room for improvement. If you're going to look at the sunny side of it, you'll have other industries driving the development, not only aviation. Maybe you can have a small-scale production facility in 10 years that is quite efficient. But I think it's exciting and I think that it will have a role. However, I don't think we'll see a future where aviation continues flying around powered by fossil fuel and claims that we re-capture the CO_2 emitted.

What impact on investor appetite does the value proposition (aside from decarbonization) of each decarbonization technology have, for example, new propulsion aircraft, SAF, Carbon Capture, etc.? They all have different value propositions apart from the decarbonization aspect. Are some sexier than others?

Niklas: If we look at sustainable technologies at large, solar, wind, and batteries have had the most well-known fantastic development, so impressive. And what's the reason for that? Well, it's not only the sustainability factor, they are now more than competitive. Solar started off being about double as expensive generating energy than the next best. Now it's 40% cheaper than anything else. That's the best driver you can find: when you have the sustainability aspect, but you also lower the operating cost. In the best of worlds, we will be able to see that in short-haul aircraft new propulsion technology coming to market in the next 10 years. For an airline, what can be better than that? You get both the sustainable factor and you lower your operating cost. If we look at SAF, the cost will come down, but will it come down below current jet fuel level? It might not, because we're competing with geology and Mother Nature, which has done maybe 80% of the job. The impact is that it will be more expensive to fly. Either you as an airline will have to pay for carbon credits or you will have to pay for more expensive fuel. But hopefully that delta will not be as large as it is today. I have seen numbers suggesting SAF will be on average two times Jet A fuel price in the future overall. Lower the operational costs or lower investment costs, and if you are able to hit both spots, you have a very good driver.

Lukas: I'd be happy if sustainable aviation as a whole starts becoming sexier. This is the major potential I see there because, as Niklas said, the costs will come down the more the technology matures. But if people really believe in something or want to be part of something, then they will accept a higher cost. And this is a chance for this industry. Many people like flying, aviation is still an industry that is different from many other industries because it has this magic to it. We've always been very good at making people have the sparkling in their eyes of the special thing about this industry. This is a part of the solution, I believe, for the aviation industry when it comes to sustainability: make the product so that people want to use it, even if it costs more, because I feel that people will pay more for it if the product is really convincing and good.

Niklas: Very good point. I think aviation ends up by default playing defense a lot. But the industry actors need to embrace this transformation.

5. Getting up to date with sustainability reporting

Paul Sheridan

Paul Sheridan, *leader of PwC Ireland's Aviation Finance Advisory Services team offers a quick, non-exhaustive view of the current sustainability reporting framework. The introduction is meant to provide a practical context of how the European Corporate Sustainability Reporting Directive (CSRD) has evolved and how aviation stakeholders must align with the new requirements.*

Introduction

The Corporate Sustainability Reporting Directive, or CSRD as it is now commonly known, is already making an impact on the aviation leasing and financing community, coming into full effect this year, with the first round of reports published next year. CSRD is a legislative disclosure requirement, now in use, by the European Commission to revise and replace the existing Non-Financial Reporting Directive (NFRD), which has been in force since 2017. Not for the faint of heart the initial investment of setting up the CSRD reporting structure for large established leasing firms is substantial as this journey encapsulates all parts of the business.

CSRD applicability (two of three):

€40m in net turnover
€20m on the balance sheet
250 or more employees

The first step is to determine whether CSRD is applicable to you. Using a quick test, large companies in EU Member States that meet two of the three criteria are considered to be in scope. This includes having 250 employees or more, and/or a net turnover of €40m and/or assets of €20m on the balance sheet. However, these thresholds could increase by 25% to €50m net turnover and €25m in assets to account for inflation. With 100+ KPIs and over 1000 qualitative and quantitative data points to gather, companies need to understand what is applicable to their business models and what can be removed from consideration through an in-depth gap analysis.

As CSRD has a double-materiality reporting requirement (impact and financial), and lessors need to account for upstream, direct contributions and downstream exposure, especially to lessees – the analysis will be far reaching, when taking into consideration their Scope 1,2 and 3 reporting requirements. We expect this type of assessment will take 3-4 months and should be accomplished this year, depending on your reporting requirement. To make things more complicated, limited assurance is required initially transitioning to reasonable assurance over time.

Given the complicated and multilayered financing and ownership structures of most aircraft lessors, especially with larger global footprints, it is recommended that you consult with your advisors as to what might be considered in and out of scope.

With regards to timing, large companies already subject to the NFRD will be the first to be impacted from 2024 with their first annual report published in 2025. Large companies that are not subject to NFRD will start their compliance from 2025, and publishing in 2026.

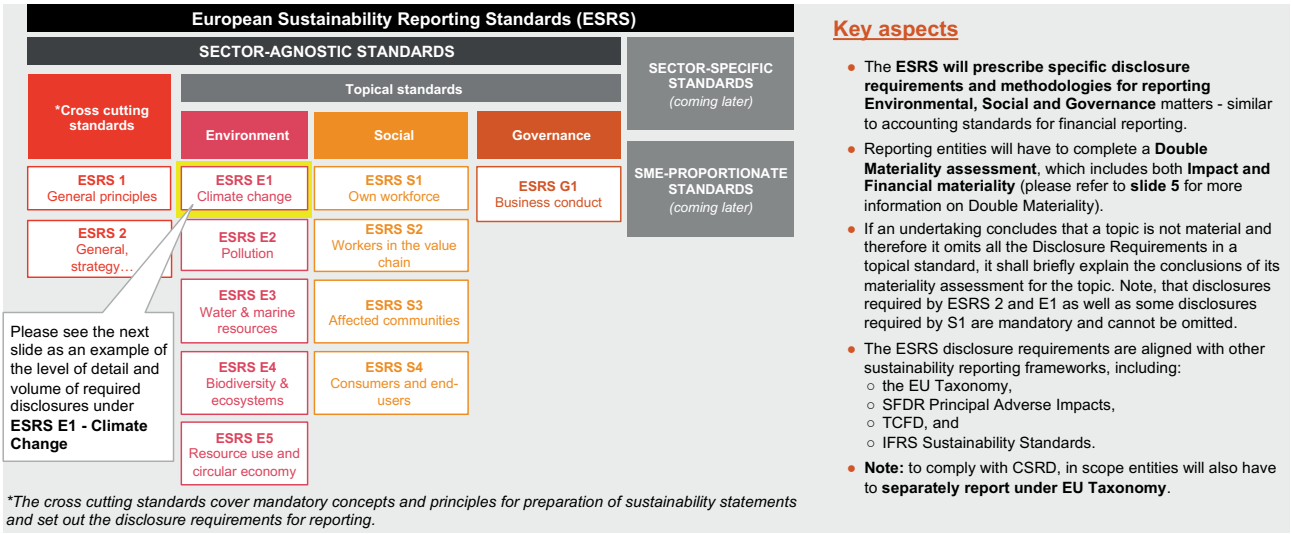
Background and rationale of the CSRD and ESRS

A bit of background might help better understand the evolution of CSRD and the European Sustainability Reporting Standards, or ESRS. As previously mentioned, CSRD is a legislative disclosure requirement, now in use, by the European Commission to revise and replace the existing Non-Financial Reporting Directive (NFRD), which has been in force since 2017. The NFRD required large, listed companies and certain other public-interest entities (PIEs) to disclose information on their environmental, social, and governance (ESG) performance and impacts. However, the NFRD was criticized for its limited scope, inconsistent quality, and lack of comparability and reliability of the reported information.

CSRD aims to address these shortcomings and to align the sustainability reporting framework with the EU Green Deal and the Sustainable Finance Disclosure Regulation or SFDR, which are the key policy initiatives to achieve the EU's climate and sustainability goals and to foster the transition to a low-carbon and resilient economy. CSRD also responds to the growing demand from investors, regulators, and other stakeholders for more comprehensive, consistent, and transparent sustainability information from companies.

The ESRS standards were developed by the European Financial Reporting Advisory Group (EFRAG) and adopted by the Commission to operationalize the CSRD. The twelve new ESRS standards (seen below) will define the specific disclosure requirements and metrics that companies will have to follow to comply with the CSRD. ESRS will consist of sector-agnostic and sector-specific standards, as well as cross-cutting and SME (small-medium scale sized enterprises) -proportionate standards. The principle of double materiality will be a core tenant of ESRS which means that companies will have to report on both the financial impact of ESG risks and opportunities, and the sustainability impact of their activities on the environment and society.

The twelve standards, highlighted below, span environmental, social, and governance topics and are intended to provide insight into a company's sustainability impacts, risks and opportunities, including its sustainability strategy, targets and progress, products and services, business relationships, and incentive programs.



Main features and requirements of the CSRD and ESRS:

The CSRD and ESRS have introduced significant changes in terms of the reporting and assurance requirements for companies, which they need to start preparing for now. Some of the main features and requirements are:

- **Expanding the scope of reporting entities:** CSRD will extend the reporting obligation to all large companies and all listed EU companies, regardless of their size, as well as to certain non-EU companies operating in the EU. This will increase the number of reporting entities from around 11,000 under the NFRD to around 49,000 under CSRD. CSRD also applies to consolidated and individual entities and will be a mandatory component of the management report.
- **Expanding the content of sustainability reports:** CSRD now requires companies to disclose information on a wider range of sustainability matters, such as climate change, biodiversity, human rights, anti-corruption, and governance. CSRD also requires companies to disclose information in line with EU Taxonomy, which is a classification system of economic activities that contribute to environmental objectives. ESRS specifies the disclosure requirements and metrics for each sustainability matter and will be updated regularly to reflect the evolving needs and expectations of stakeholders.
- **Enhancing the quality and comparability of sustainability information:** CSRD requires companies to report sustainability information in a digital and machine-readable format, using a common electronic reporting template and tagging system. This will facilitate the accessibility, usability, and analysis of the reported information by various users, such as investors, regulators, and civil society. CSRD also mandates companies to ensure the consistency, coherence, and reliability of the reported information, and to provide a clear link between the sustainability and financial information.

- **Strengthening the assurance and verification of sustainability information:** in scope CSRD companies need to obtain an independent assurance of their sustainability reports, starting with a limited assurance and transitioning to a reasonable assurance in the future. The aim will be to increase the credibility, confidence, and accountability of the reported information, and will also entail a greater responsibility of the management and governance of the reporting entities. CSRD also establishes a common EU oversight and enforcement mechanism, involving the cooperation of national authorities and the European Securities and Markets Authority (ESMA).

CSRD and ESRS are already in effect, which means that the first sustainability reports under the CSRD and ESRS will be issued in 2025 for the financial year 2024. However, CSRD and ESRS will also depend on how the legislation is transposed into national law by the member states, which may introduce some variations or additional requirements.

Implications of CSRD and ESRS for the aviation industry

Both CSRD and ESRS have significant implications for the aviation industry, which is one of the most affected and challenged sectors of the climate and sustainability agenda. Aviation stakeholders will have to adapt to the new reporting and assurance requirements, and to the increased scrutiny and expectations of its stakeholders, especially in terms of its environmental and social impacts and performance. The implications of CSRD and ESRS will vary depending on each segment of the aviation industry, as discussed below.

Investors

Aviation investors such as asset managers, pension funds, and insurance companies, will have to comply with CSRD and ESRS as reporting entities, as well as to use the reported information by other entities as users. Investors now have to disclose how they integrate ESG factors into their investment decisions and risk management, and how they align their portfolios with EU Taxonomy and the EU Green Deal objectives. Investors also have to assess the ESG performance and impacts of the companies they invest in, such as aircraft leasing companies and airlines, and to engage with them on their sustainability strategies and targets. Investors will be expected to benefit from the improved quality and comparability of the sustainability information under CSRD and ESRS, as it will enable them to make more informed and responsible investment choices, and to meet the growing demand from their clients and beneficiaries for sustainable finance products and services.

Aircraft lessors

Aircraft lessors are a critical segment of the aviation industry, as they own and lease a large share of the global aircraft fleet to airlines and other operators. Currently, according to the AFJ's Fleet Tracker, 45% of commercial aircraft are leased, down from a peak of 59% prior to the Covid pandemic.

The lessor exposure to the industry remains very high, and a significant number of lessors, and related entities will now have to comply with CSRD and ESRS as reporting standards. Aircraft lessors will have to disclose detailed information on their ESG performance and impacts, such as their portfolio carbon footprint, their energy efficiency, their social and labor practices, and their governance structures and policies; along with their adherence with EU Taxonomy, which will define the criteria and thresholds for the environmental performance of the aircraft and the aviation activities. Lessors will face the challenge of collecting and verifying the sustainability information from their customers and suppliers, and of ensuring the consistency and reliability of the reported information across different jurisdictions and standards. In the big picture, lessors will also have the opportunity to enhance their reputation, competitiveness, and innovation, by demonstrating their commitment and contribution to the sustainability transition of the aviation industry, and by offering more sustainable and efficient aircraft and competitive leasing solutions.

Airlines

As airlines are the main operators of the aircraft, they are also the most exposed and vulnerable to the climate and sustainability agenda. Similar to lessors and investors, airlines will have to address the information needs and expectations of their stakeholders, such as investors, regulators, customers, and employees. Airlines will now have to disclose information on their ESG performance and impacts, such as their greenhouse gas emissions, their fuel consumption, their noise and air pollution, their customer satisfaction, their employee welfare, and their governance practices and policies. Airlines will also have to disclose information with regards to EU Taxonomy. It is expected that operators will be able to leverage their sustainability information to communicate and engage with their stakeholders and passengers, and to showcase their efforts and achievements in improving their sustainability performance and aligning with the EU Green Deal objectives.

All of these groups will have a similar overlap when it comes to their value chains under Scope 1, 2 and 3 emissions, with each of them being reportable to the other. As such, consistent data must be adhered to and the ability to be transparent with one another will be a key in ensuring quality and reliable reporting.

Conclusion

Ultimately disclosures will have to be a two-way street, especially for European lessors and operators. As there will be significant overlap of exposure, airlines will need to disclose to their leasing partners on their emissions, and leasing partners will need to disclose to their airline relationships the same. Having the advantage of a clearinghouse would be beneficial for all parties and would allow for better and more consistent transparency for all parties involved.

These reporting requirements will have a profound impact on the sustainability reporting landscape, and will affect the aviation industry in various ways, depending on the segment and the scope of the reporting entities. The aviation industry will have to prepare for the new reporting and assurance requirements, and to address the increased scrutiny and expectations of their stakeholders, especially in terms of their environmental and social impacts and performance.

The aviation industry will also have to adapt to the different scenarios of the CSRD and ESRS implementation, and to the potential alignment or misalignment between the EU and international reporting frameworks. The CSRD and ESRS will pose significant challenges and opportunities for the aviation industry and will require a strategic and proactive approach to leverage sustainability information for value creation, innovation, and competitiveness.

In closing, it is recommended that organizations immediately attack their disclosure efforts in three discreet phases:

Assessment. In this phase, the firm determines which, if any, of its legal entities are in the CSRD's scope and decides how to consolidate and report information from them. Next, the firm carries out a double materiality assessment, a procedure for determining which sustainability topics and associated data points to report on.

Transformation. Once the firm understands the extent of its reporting requirements, it analyses its reporting capabilities and identifies and fills gaps that could keep it from meeting requirements. In this second phase, it establishes the processes, technology tools, datasets and staff skills needed to report hundreds of performance metrics in a way that is accurate, consistent and ready for an external audit.

Reporting. With new capabilities in place, in the final phase, the firm captures all required data, consolidates the information and reports accordingly, articulating a narrative on its sustainability performance that will be meaningful to investors, regulators and other stakeholders.

For more information visit the PwC Ireland at pwc.ie.

6. Rapid, radical, and resolute – what aviation needs to do for climate neutrality

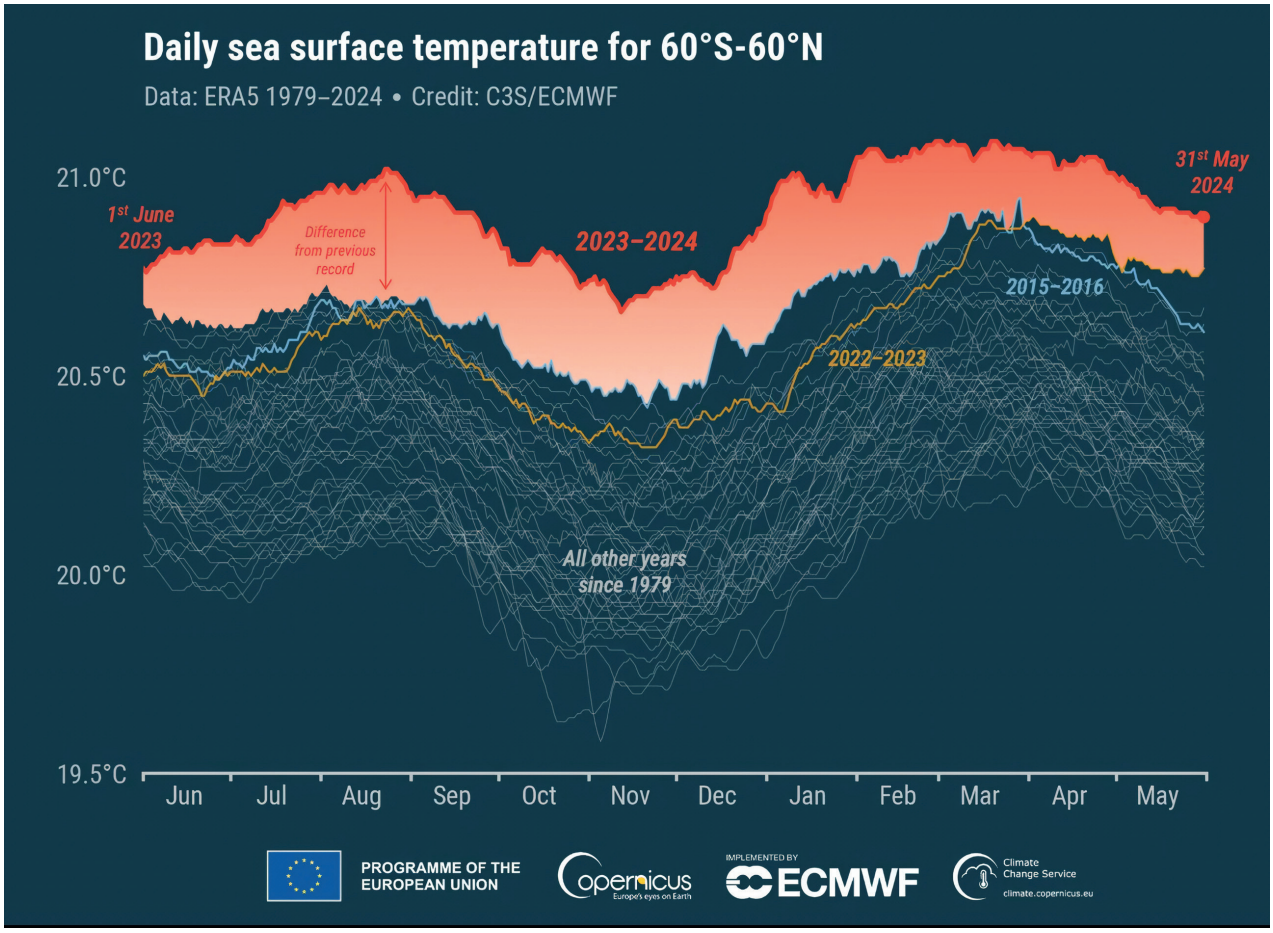
Dr. Ram Kamath

Dr. Ram Kamath
Coordinator – Transition to Climate Neutrality,
Bauhaus Luftfahrt

Decarbonization pathways for aviation frequently strive to align with the Paris Climate Agreement. The agreement to limit global warming to 1.5 degree Celsius, is however based on carbon budgets that are probabilistic. In 2020, the IPCC estimated that the remaining global carbon budget for a 50% chance of staying within 1.5°C of warming was around 500 GtCO2. This implies that even if we adhere to this budget, there is still a 50% chance that warming will exceed 1.5 degrees. Perhaps this is the pessimistic view, and one could argue that a 50% chance of curbing warming is still significant.

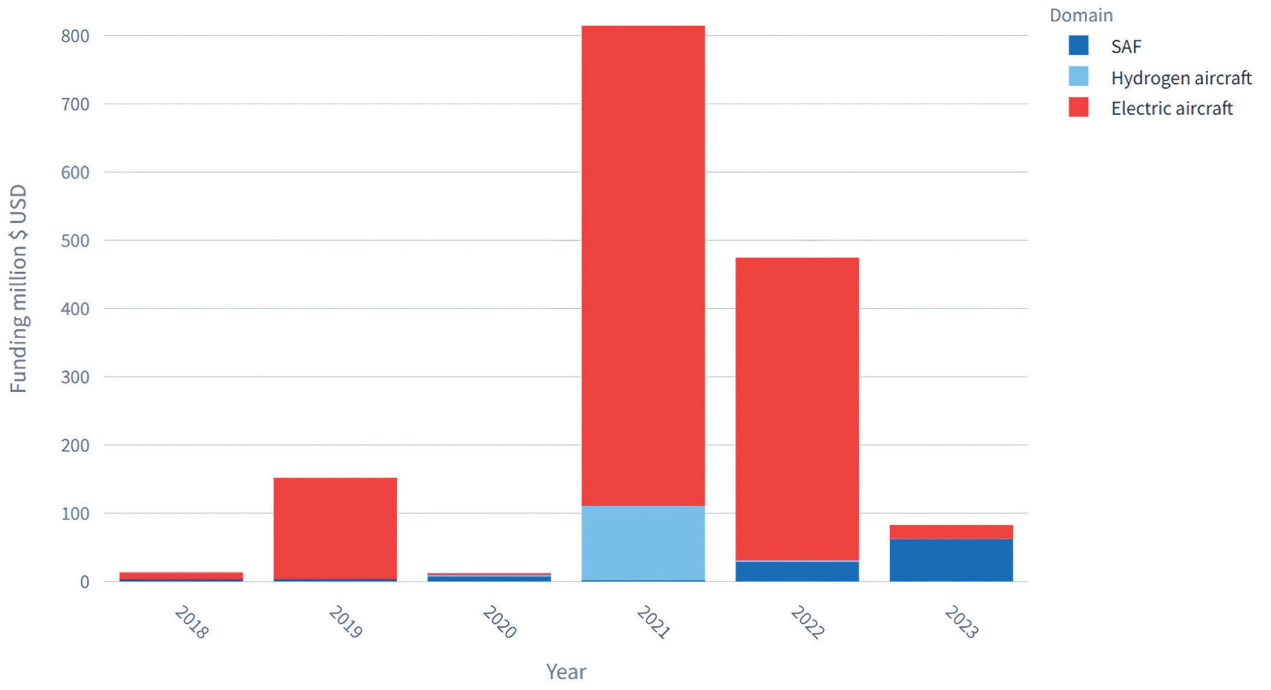
However, the planet's Equilibrium Climate Sensitivity (ECS)—the expected warming if greenhouse gas levels double from pre-industrial levels— is also probabilistic. In other words, there is significant uncertainty about the rate of warming as GHG emissions continue. There is in fact a troubling chance (~20%) of the ECS being greater than 5 degrees. There are already indications that the planet is warming faster than expected – 2023 is the warmest year ever in the modern temperature record. Since 2020, climate change indicators and impacts have worsened, with record number of floods, fires, droughts etc.

The primary implication for aviation is that 2050 may be too late for decarbonization.



The world is heating up at an unprecedented rate: 2023 is the warmest year ever in the modern temperature record, with warming seeming to accelerate since 2020 (source -Copernicus Climate Change Service).

However, can aviation move that rapidly? Two features of the sector, which make aviation possibly the hardest sector to transition, are its Capex-heavy nature, and its long innovation cycles. Generally, new aircraft, fuel programs, and infrastructure projects take decades from conception to full deployment. These long timeframes bring with them significant risks relating to changing regulations, and eventual market adoption. These risks retard investments in aviation's transition. Case-in-point is the sluggish ramp-up of eSAF production in Europe. In spite of ReFuelEU Aviation imposing progressive SAF blending quotas, it has resulted in few SAF projects reaching final investment decisionsi, and relatively low investments in SAF startups.



Global VC investments in SAF lag behind other green-tech: even though there is widespread agreement that SAF is the most immediate decarbonisation lever in the short-to-medium term, startups producing (e)SAF struggle to attract as much funding as those producing electric- or hydrogen-aircraft (source – Bauhaus Luftfahrt's DIPAT analytics tool).

Moving forward through uncertainty

To help stakeholders tackle the uncertainties regarding the eventual effects and costs of hydrogen aircraft and different types of SAF, and the impact of different regulations, Bauhaus Luftfahrt developed its "Airline Decarbonisation model" in 2023. Here, we compare three cornerstone scenarios, to highlight the urgency of taking radical, resolute measures.

The SAF-led decarbonization scenario

In the first scenario, sustainable aviation fuels capture the lion's share of block-energy; and hydrogen-powered aircraft are never introduced. SAF consumption moves from essentially zero, to 800 megatons (~ 35 million terajoules) in 2070. This ramp-up accounts for 100% of energy needs from 2048. 77% of the SAF consumption in 2070 is composed of power-to-liquid (PtL) fuel produced using direct-air-capture (DAC).

SAF's contribution is supplemented by cleaner conventional aircraft, which are introduced between 2030 and 2035 for different market segments. For the regional, short-medium range, and long-range segments, the efficiency gains are 16%, 15%, and 14% respectively. Succeeding generations are developed 15 and 30 years later. Less efficient aircraft are retired at a rate of 2% annually.

The SAF and radical conventional aircraft decarbonization scenario

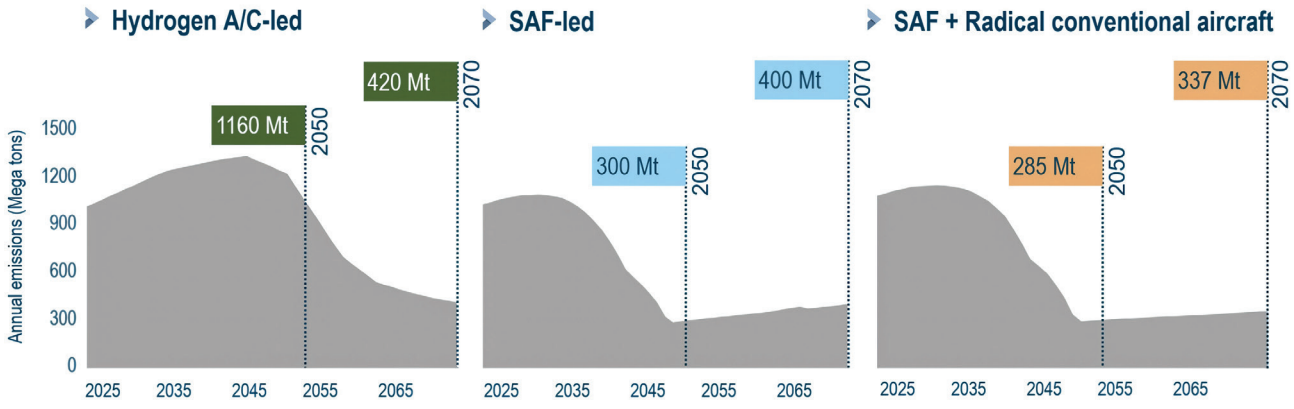
In this second scenario, we combine significant ramp-up of SAF consumption with new aircraft concepts that offer radical improvements in fuel-burn efficiency of 50% for all segments. These aircraft are introduced between 2040 and 2045, and less efficient aircraft are retired at a rate of 2% annually.

The hydrogen aircraft-led decarbonization scenario

To help stakeholders tackle the uncertainties regarding the eventual effects and costs of hydrogen Here, we have hydrogen aircraft being introduced for the three segments between 2040 and 2050. We also have cleaner conventional aircraft being introduced between 2030 and 2035, with the same efficiency gains as in the first scenario. However, we do not have the development of succeeding generations of cleaner conventional aircraft. Less efficient aircraft are retired at a more progressive rate of 4% annually.

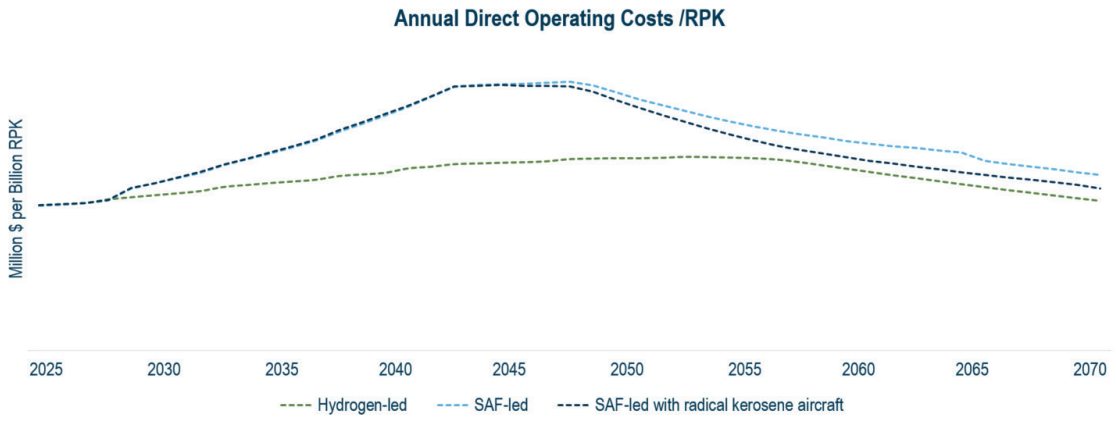
Because the key lever is hydrogen aircraft, SAF consumption only climbs to 260 Mt in 2070 (48% of which is PtL produced using DAC).

Comparing the scenarios, the SAF + radical aircraft scenario seems to be the most effective. For both the SAF, and SAF + radical aircraft scenarios, decarbonization (excluding residual scope 3 emissions) is achieved by 2047; while in the hydrogen aircraft-led scenario, it is achieved in 2070. Combining SAF with radical aircraft leads to slightly lower cumulative emissions, and lower levels of residual emissions (thanks to lower SAF consumption).



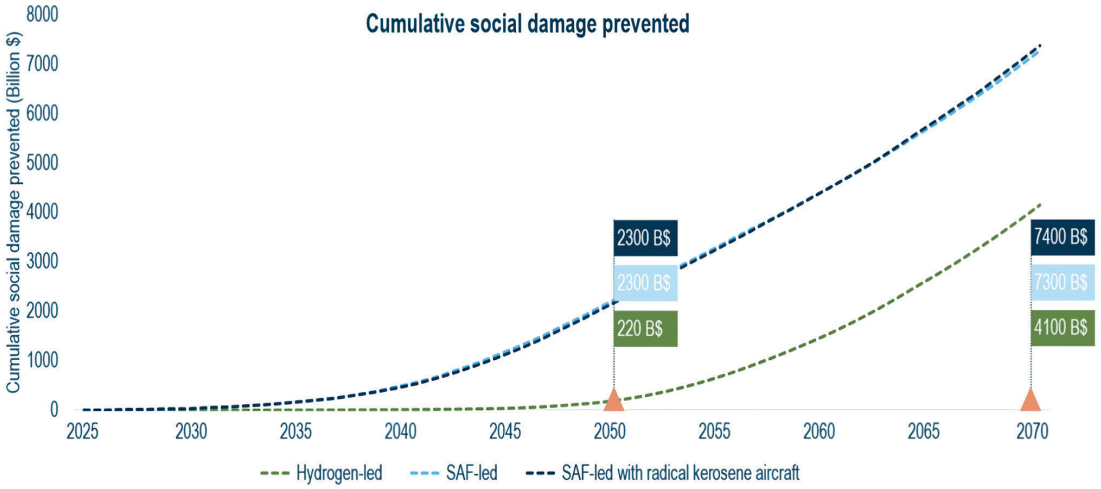
Comparing the effectiveness of our scenarios: A rapid ramp-up of SAF consumption, combined with radical conventional aircraft, seems to the most effective pathway to decarbonization.

Comparing the scenarios on operating costs for an airline, we see that the hydrogen aircraft-led scenario leads the pack. What we see is that SAF-led decarbonization has much higher Direct Operating Costs/RPK ratio for large periods of time. This is not surprising since eSAF gradually takes the lion's share of the SAF bucket. With the introduction of cleaner conventional aircraft, the Opex does decrease, but never reaches the levels of the hydrogen aircraft scenario.



Comparing the efficiency of our scenarios: From the point of view of an airline, it seems that decarbonization via hydrogen aircraft is the most cost-optimal pathway.

At least from the perspective of airlines, the hydrogen aircraft-led scenario seems to be optimal. Airlines will be able to decarbonize by 2070, and they will end-up with much lower costs than if SAF was the key lever. However, is it the best scenario for society as a whole? To answer that question, we use the metric of social cost of carbon dioxide, which monetizes the value of damage caused to society, by an incremental ton of CO_2 emitted[ii]. We first estimate the incremental emissions for each scenario, in comparison to a "business-as-usual" context. We then compare the damage prevented by the scenarios, using a social cost of 185 $ per ton of incremental CO_2 emissions[xxx]. This comparison demonstrates that the SAF + radical aircraft pathway prevents the most damage, and thus, is the best scenario for society as a whole.



SAF is the key lever, today

The above scenario comparison is not meant to proclaim SAF as a silver bullet to aviation's challenges to transition. Rather, it is meant to isolate the possible contributions of the technological levers at our disposal. The comparison is also meant demonstrate the profound importance of ramping up the production of SAF, specifically PtL fuels. As things stand, there is still considerable uncertainty regarding how hydrogen aircraft –in terms of entry into service and aircraft size- will be introduced.

What we do know today is that SAF is compatible with current infrastructure; it can be used immediately. SAF is projected by multiple studies to play the decisive role in decarbonizing aviation by 2050. Even in our hydrogen aircraft-led scenario, which takes very optimistic assumptions for the introduction of hydrogen propulsion, SAF accounts for 28% of cumulative emissions saved.

Most of this saving comes from PtL SAF made using DAC. Aviation's stakeholders need to move rapidly, resolutely, to spur the development of these radical technologies. We present here, some policy and financial measures required to ensure eSAF fulfils its potential, and aviation decarbonizes well before 2050:

	Measures for supporting eSAF
New policy measures	• Introduce tax incentives to subsidize SAF production, always along with clear sub-quotas for eSAF. • Collaborate across stakeholder groups and across borders, to develop and adopt technical standards for eSAF production. • Establish certification programs to verify the sustainability and carbon reduction benefits of eSAF. • Offer credits or incentives for airlines that blend synthetic SAF with conventional jet fuel. • Implement, and gradually raise, taxes on aircraft emissions; which are then used to subsidise eSAF
New financial mechanisms	• Provide "use of proceeds" green-loans, sustainability linked-loans with standardized structures and sustainability performance target metrics. • Form Public-Private Partnerships that leverage public funding and private sector expertise. • Introduce risk-sharing mechanisms such as first-loss loans, syndicated offtake agreements, and guaranteed partial pass-through of future cost reductions to offtakers

Radical policy and financial measures for eSAF: for eSAF to fulfill its potential, we need systemic changes that will ensue from new policy measures, and new financial mechanisms.

7. View from Japan: Cirium Ascend Consultancy

Toshimitsu Sogabe

Toshimitsu Sogabe, *Aviation Consultant in Cirium Ascend Consultancy's Tokyo office, reviews Japanese operating-lease market trends with respect to the transition towards net-zero*

Asia-Pacific, including Japan, has been perceived as lagging behind other geographical counterparts when it comes to the net-zero transition. However, Japan has been accelerating its efforts towards a carbon-neutral society. In fact, Japan was one of the most conscious countries regarding carbon neutrality when the Kyoto Protocol was first adopted in 1997 and came into effect in 2005.

At that time, Japan was truly committed to solving these issues, exemplified by Toyota introducing the Prius in 1997, and the term "Sho-Ene" (energy conservation) becoming very popular within the Japanese society. The major challenge with the Kyoto Protocol was the lack of alignment among major countries on emission targets, leading to the USA not ratifying and Canada withdrawing in 2012.

Since then, the Paris Agreement has effectively replaced the Kyoto Protocol, now involving crucial countries such as the USA, India, and China. Although Japan has been proactive for over a decade, there is a perception within Japan that other countries, which have largely ignored these issues in the past, have suddenly become politically motivated to push forward, as evidenced by the success of electric vehicle manufacturers in their respective markets.

Japan nonetheless continues to take this matter seriously, particularly in aviation. Several major Japanese companies are partnering with sustainable aviation fuel (SAF) producers, and Japanese airlines have committed to SAF usage. Additionally, the Japanese government has announced a program to study and develop hydrogen-electric propulsion aircraft, aligning with Japan's plans to be carbon-neutral by 2050.

However, the motivation among small and medium-sized entities (SMEs) in Japan, which form the main base for JOL/JOLCO investors within aircraft finance, is not as strong as that of large public corporations or government-related entities. In recent years, some sustainability-linked JOLCOs have closed in the market, however it appears that airlines and lenders, both domestic and foreign (likely pressured by stakeholders), are the primary promoters when it comes to these types of transactions, rather than the equity underwriters.

In recent times it has become increasingly apparent that JOL/JOLCO equity underwriters are currently putting more emphasis towards mid-life assets. This can be partly explained by the depreciating yen, which makes smaller ticket-size assets more appropriate. The situation is amplified by the fewer opportunities around new-technology aircraft, as supply-chain disruptions and other apparent issues create a drag on OEM production-rate increases.

However, one can say this may also be due to insufficient incentives or tariffs for these SME investors to focus on new-technology aircraft. The tendency of SMEs to be less conscious about the net-zero transition, when compared with large corporations, is not unique to Japan and seemingly a problem that is seen worldwide. It is evident that larger governmental involvement is required for all companies, big and small, to follow through such challenging initiatives. The SMEs and large corporations equally would also have a duty to show what is required for them to achieve their targets, so that they can pressure the government to reverse-engineer what measures will need to be taken, and ultimately to execute such, in order to help out the society as a whole.

Cirium Ascend Consultancy believes pushing each country's government, including Japan, to introduce initiatives that encourage companies to sustainably meet their net zero target to be a key factor, as this will be pivotal in driving business transitions.

8. Chinese institutions in aviation embrace sustainable finance

Eduardo Mariz

Eduardo Mariz, *Sustainability Lead at Ishka and a member of impact's reporting workstream, examines recent interest in sustainable finance transactions by two Chinese-backed leasing companies and one Chinese airline.*

Sustainable finance has been a growing phenomenon in aviation in recent years, with over 20 airlines or airline groups having now closed at least one sustainable finance deal and deal announcements growing around 60% annually since 2021. According to data by Ishka, an impact member, as of June 2024 there are 52 publicly known sustainable finance deals involving airlines and/or lessors. Until now, the vast majority of borrowers have been European airlines, with European (particularly French) and Japanese lenders the most active in the market.

And yet, transactions over the past six months appear to tell a different story. Four of the seven sustainable finance transactions in aviation since December 2023 have involved two Chinese-owned leasing firms and one Chinese airline. Chinese lenders have also become more prominent transaction parties. In light of this new trend, impact examines the interest of some Chinese aviation firms in sustainable finance.

CALC's leading role

China Aircraft Leasing Company's (CALC) burgeoning sustainable finance activity has not only positioned the firm at the forefront of this trend, but also as the aircraft lessor with the most sustainable finance transactions to date. The full value aircraft solutions provider – which in addition to leasing also offers MRO, component sales, and disassembly services – has issued three transactions with sustainable finance features:

- In 2022, it issued a RMB1 billion (approximately $140 million) debut **low-carbon transition bond** through wholly owned subsidiary China Asset Leasing Company Limited;
- In 2023, through the same subsidiary it completed its first and second tranches of **low-carbon transition corporate bonds**, with use of proceeds in the "low-carbon transition field" through the purchase of fuel-efficient aircraft for fleet replacement;
- Earlier this year, it debuted the first-ever **sustainability-linked aircraft PDP syndicated loan** with a placement size of $360 million. This transaction has been linked to two sustainability performance targets (SPTs): increasing the share of latest-technology aircraft in CALC's fleet to 25% by the end of 2025 and increasing professional training hours for its workforce to 3,281 hours by 2025.

CALC told Impact it plans to continue to use green finance for fundraising and is considering adding "certain sustainability-linked incentives" to lease structures, such as indicators related to fuel efficiency and carbon emissions. "We believe by offering such leases, CALC could encourage lessees to prioritise sustainability and environmental performance throughout the lease term," the company shared.

CALC's motivations

Responding to questions by Impact on what motivated these transactions, CALC noted that its use of sustainable finance stems from a desire to build CALC's reputation as a "socially responsible company," to strengthen its relationship with stakeholders, to respond to "growing demand for sustainable investments among investors" including attracting a "broader range of investors who prioritize ESG considerations," and to mitigate market risks associated with environmental and social factors.

CALC also shared a belief that ESG target-setting and indexing will continue to become a priority for airlines and financiers. "It is likely that such indexes will be incorporated in financings and the cost of the financings and possibly even the availability of financings will be impacted if these indexes are not met," a company representative noted.

The lessor acknowledged that "traditional green financing options may be limited for aviation companies" but transition finance and sustainability-linked structures are opening up sustainable finance opportunities for companies in the sector. The company also sees disengagement with sustainable finance as a long-term risk. "It is likely that investors and financiers will refrain from doing transactions with companies that do not accept sustainability linked products. Some banks have already said that they will only finance sustainability-linked transactions. Investors are sure to follow," the firm said.

CDB Aviation issuances

The other Chinese-backed lessor using sustainable finance is Dublin-headquartered CDB Aviation, the Irish subsidiary of CDB Leasing, a leasing company backed mainly by the China Development Bank. The lessor closed its first and second sustainability-linked term loans in December 2023 and April 2024 respectively, raising a combined $1.23 billion tied to two environmental and one social KPIs: CO_2 intensity reduction, latest-generation aircraft fleet share, and increasing Diversity, Equity, and Inclusion (DEI) related training hours.

The CDB Aviation issuances followed a stated objective to arrange the lessors' first sustainable finance instrument in 2023. The company's prioritization of sustainable finance in its ESG strategy also includes a target to "develop sustainability-linked leases and other innovative sustainable finance products" by 2025. "For CDB Aviation, sustainable finance instruments such as sustainability-linked bonds, loans and leases are a key tool that we can leverage to positively influence the industry and help us to deliver on our sustainability strategy," the lessors' 2022 sustainability report notes.

CDB Aviation told Impact that is has "actively incorporated" ESG considerations into its growth's strategy and, in recognizing the importance of leasing and in support of industry-wide efforts address sustainability concerns, its team "has and will continue" to take ESG into account in its financial strategy as well as other efforts and initiatives.

Spring Airlines embraces China's first transition taxonomy

Shanghai-headquartered low-cost carrier Spring Airlines also brought aviation into the sustainable finance spotlight last January by becoming the first company in the country to close a loan aligned with China's first transition finance taxonomy – the Shanghai Transition Finance Taxonomy (Trial) (approximated translation of its original title: 上海市转型金融目录（试行）).

According to a report by environmentalist non-profit China Dialogue, the 310-million-yuan ($43.7 million) loan contained sustainability performance targets such as ton-kilometer emissions and the proportion of SAF used. Proceeds from the loan were reported slated for the introduction of "fuel-efficient" Airbus A320 neo aircraft.

China's policy drivers

In addition to business priorities, there are several Chinese policies encouraging sustainable finance and decarbonization target-setting:

- *Green Finance Guidelines (2016)* – Issued by the People's Bank of China (PBOC), they provide guidance for financial institutions to incorporate environmental considerations into their lending and investment activities;
- *China's 14th Five-Year Plan (2021-2025)* (drafted in late 2020) – Green financing is included, aiming to support sustainable development and environmental projects, including the use of financial instruments such as green bonds and green loans;
- *Working Guidance For Carbon Dioxide Peaking And Carbon Neutrality In Full And Faithful Implementation Of The New Development Philosophy* (2020, last updated October 2021) – which outlines China's target to reach peak emissions before 2030 and achieve carbon neutrality by 2060 – known as the "30/60" goal.

China has also established itself as a global leader in sustainable finance, with policies and regulations encouraging green bond issuances – see research by the Shanghai-based Green Finance & Development Center for more details. According to Climate Bonds, an investor-focused NGO, China was the biggest green bond market for a second year in 2023, recording volumes aligned with Climate Bonds' GBDB methodology of $83.5 billion from onshore and offshore issuance.

There are also incoming corporate requirements for listed companies to disclose ESG information. Most recently in February 2024, the country's leading stock exchanges announced guidelines mandating corporate sustainability disclosure for listed companies from 2026.

impact would like to thank CALC for its support of this piece, including a comprehensive list of frameworks in China that encourage decarbonisation, ESG target-setting, and sustainable finance.

9. Could the EU SAF mandate's openness to revision become its downfall?

Dr. Peter Smeets & Celine Coridass

Dr. Peter Smeets, *360 Asset Finance managing director, and* **Celine Coridass,** *360 Asset Finance senior analyst, delve into the intricacies of EU review clauses and the wording of ReFuelEU Aviation's Article 17 to unpack investor concerns and provide reassurance that policy amendments (the earliest of which could arrive in 2027) are unlikely to shift the core objectives of the EU's SAF mandate.*

Why investors fear Article 17

Clauses enabling the review of European legislation are not uncommon, but the scope of what can be revised varies. In the case of ReFuelEU Aviation, Article 17 compels the European Commission – the EU's main executive branch – to compile and publish a report by January 2027 and every four years thereafter on four key areas of the policy. Those four areas cover most of its scope, including possible adjustments to "the definition of SAF, the permissible fuels, and their minimum percentages as well as the level of fines."

ReFuelEU Aviation's purpose is to send a market signal to fuel suppliers and airlines to demand SAF at specific quantities over a specific period, thereby strengthening the SAF investment rationale in the EU. That core objective could be undermined if investors take the view that flexibility to review percentages, SAF definitions and the buy-out cost (i.e. fines) can alter the profitability of future SAF refineries.

Main takeaways of our analysis

The main concern by investors around Article 17 is that the EU Commission could determine in 2027 (and/or after future reporting intervals) that blending quotas will have to be adjusted, particularly if there is insufficient SAF expansion.

From a policy direction standpoint, amendments to EU laws do not generally result in the abandonment of policy objectives. With regards to ReFuel EU Aviation, this means that it can be assumed that the basic intention of the regulation including the progressing market ramp-up of SAF usage will remain in place and only the design of the measures will be adjusted.

Possible amendments to the regulation (based on the wording of reporting obligations under Article 17) include:

- adjustments to reduce cost pressure in the form of innovation aid
- support measures for production and refueling
- bridging the price difference between SAF and conventional fuel
- increasing CO_2 costs
- the extension of the minimum blending quotas over time
- the reduction of fines

Amendments could lead to the regulation becoming more precise with regard to the avoidance of carbon leakage. There is also a risk of a self-fulfilling prophecy whereby present pessimism around future unattainability of the SAF blending quotas could lead to a reluctance to conclude SAF offtake agreements, in turn impairing SAF project financing.

One useful point of reference is the recent legislative experience in Germany, where a power-to-liquid (PtL, also known as eSAF) national quota was introduced in 2021 but remained subordinated to the EU which then introduced overriding PtL quotas – which became ReFuelEU Aviation's sub-mandate for synthetic fuels in 2023. However, ReFuelEU Aviation differs from the German PtL quota as the European PtL quota starts later (2031) than that of Germany (2026, as initially planned). The question of primacy of application and factual practicability points to a postponement of the periods of the German PtL Quota or a reduction in the blending percentages.

Another lesson from Germany's recent biofuel regulatory endeavors is the country's shift from a national biofuel percentage-based quota to a greenhouse gas (GHG) reduction quota. German regulators displayed the greatest possible consistency between the old and the new system, prioritized climate protection, and did not follow legislative whims. Direct conclusions cannot be drawn from the handling of the German PtL quota for the handling of the European SAF quota due to the different legislators. However, it is clear that both legislators are aware of the relevance of regulatory consistency for the intended market ramp-up.

In conclusion, if and when competitive disadvantages arise as a result of ReFuelEU Aviation requiring amendments, those disadvantages could be mitigated much more efficiently and in accordance with the law by providing financial support than by withdrawing climate targets. Therefore, a lack of belief in the continued existence of the climate targets in the ReFuelEU is understandable, but at the same time, it is no reason for the obligated parties to succumb to the belief that they can escape responsibility for the decarbonization of aviation. To prevent gloomy self-fulfilling prophecies, politicians should live up to their responsibility to communicate with investors and make improvements to the supporting measures of ReFuelEU Aviation.

360 Asset Finance (360af.de) is a Management Consulting Firm based in Frankfurt/Germany that advises in the field of corporate & sustainability finance with a focus on aviation. An extended nine-page version of this analysis can be downloaded from impact's website: https://impact-on-sustainable-aviation.org/shared-files/1971/?ReviewClauseRefuelEU_Final_20240430_revised_en2.pdf&download=1

10. impact interviews leaders in sustainability

Alison O'Connor

Alison O'Connor
Avolon's Vice President of Sustainability
Avolon

Alison O'Connor *is VP Sustainability at Avolon, leading the development and execution of Avolon's Sustainability agenda. Prior to her current role, Alison spent over a decade working as a risk analyst in a number of aircraft lessors and is an active contributor at both industry events and bodies to accelerate the decarbonization of aviation. Alison holds a BA (Psychology) and MBS (Management and Organizational Studies) from University College Dublin and a MSc. (Cognitive Neuropsychology) from Oxford Brookes University and a Diploma in Financial Management (ACCA) from Dublin Business School.*

You assumed the position of Avolon's Vice President of Sustainability in 2023. Before that, you advanced through various risk management roles in aircraft leasing, including at Avolon. How did sustainability play a role in your previous positions?

I have worked in the aircraft leasing industry for more than a decade. As the VP of credit risk my role ranged from monitoring our airline customers to assessing the risks that they face and escalating any concerns. In addition to the lease counterparties, we also looked at the wider industry across different regions and, of course for decades now, the impact of flying on the environment has been known. As a result, airlines are facing an increasing number of ESG risks. For example, the Flygskam movement that emerged in the Nordics in the late 2010s. That movement was impacted by Covid-19, but customer sentiment is changing. As such, ESG has become increasingly important for analysts to assess both in terms of increasing regulatory requirements that our customers must meet and also society's view of flying and how that impacts the behavior of our customers. So, from 2020, I was engaged in a number of workstreams to understand the impact of regulatory change and, most significantly, CORSIA on our customers. I developed an ESG rating scorecard for all our customers that standardized our analysis of their ESG credentials. Then as ESG became an increasing part of our jobs, we increasingly looked at ways to support our customers on sustainability goals.

From materiality and portfolio choices to new technologies and governance considerations, sustainability is a big remit. What aspects of your new job have proven most challenging?

It's a big, broad remit and one that I can't manage on my own. I've moved from being transaction-focused to managing multiple projects, from CSRD implementation to executing on our sustainability commitments, and collaborating with other industry partners to make impactful change. There are so many opportunities for collaboration, be it our investment in eVTOLs, our research into SAF, or our work in the circular economy, all of which we outline in our sustainability report. The challenge can be determining which opportunities we can focus on to have the greatest impact, given our resource constraints and the timeframes. The space also requires bravery and a leap of faith, as nobody knows exactly how we are going to achieve net zero.

Another example where project management can help maximize our impact is my role in supporting Avolon's diversity and inclusion committee and the corporate social responsibility (CSR) committee, both led by the employees. Last year we launched our D&I strategy to address some of the challenges of the industry including lower participation of females and minorities at senior positions. On CSR, activities last year included a donation of over €550,000 to 40 individual projects, including the center piece of our volunteering day where rejuvenated the grounds and facilities of 3 charities working to support women and children who have experienced domestic abuse.

As the third-largest lessor in the world, Avolon's portfolio commitments are a reference for other players in the sector. One of those commitments is to ensure that by 2025 over 75% of your portfolio (by net book value) is made up of latest-technology aircraft, up from 60% in 2023. Avolon has upheld this target despite recent OEM delivery delays, what makes it so important?

Given the long-term nature of technological development in aviation, financing the transition of the global fleet to new technology aircraft as quickly as possible is the most impactful near-term action that Avolon can take to reduce aviation's carbon impact. New technology aircraft have the most advanced materials, engine design and manufacturing process to improve the aircraft fuel efficiency. They reduce hazardous carbon, nitrogen oxide, and other emissions, including noise. A latest-generation aircraft is about 15% to 20% more fuel efficient than the previous generation, hence our focus on increasing the percentage of new technology aircraft in our fleet. OEM delays for sure cause challenges to our target, but we continue to play a key role in the new-technology delivery and this transition with the ramp-up of the delivery of our aircraft in 2025, and with our order of 200 aircraft in 2023, which will deliver out beyond 2030. It will cost over $4 trillion to complete the transition of the global fleet to new-technology aircraft, and lessors will play a crucial and central role in helping airline customers finance this transition.

Avolon was among the first lessors to deeply engage with SAF's scale-up challenge by supporting a feasibility study examining SAF production in Ireland (published in 2023). Aircraft Leasing Ireland (ALI), of which Avolon is a member, continues to actively support SAF research and development. As the SAF scale-up moves from planning to tangible action, where can leasing platforms continue to add value?

Our support of the Irish domestic SAF industry continues through our collaboration with industry peers through Aircraft Leasing Ireland (ALI) university PhD research projects that start this year. The role of lessors is to continue to support the research and development of SAF production and collaborate with other industry partners to influence policy and working with government, who can play a key role, both in terms of incentives, providing infrastructure, and supporting research and development.

The establishment in 2021 of Avolon-e - focused on investment in zero-emission eVTOL - has made Avolon a frontrunner among lessors examining clean propulsion technologies. More recently, Avolon communicated it is also interacting with several manufacturers of larger (5+ seats) Conventional Take-off and Landing aircraft powered by new clean technologies. Very few large lessors have so far shown an interest in clean propulsion technologies (hydrogen, battery-electric, hybrid). What has motivated Avolon to take an interest in this area?

SAF is expected to be the largest part of achieving net zero, but the development of new technologies is also a key enabler to decarbonize the industry. We've developed a deep understanding and knowledge of what the aircraft of the future might look like and the challenges the wider ecosystem faces to decarbonize.

We have hosted events to bring stakeholders and industry stakeholders together, to share insights into developing technologies, and we also want to support our airline customers in their path to decarbonization.

Including Avolon, a vast number of aircraft leasing companies are based in Ireland, where EU laws on corporate sustainability reporting (CSRD, EU Taxonomy criteria) have recently taken effect and will impact the requirements for the upcoming reporting periods. What effect will greater sustainability disclosure have on aircraft lessors including Avolon?

We are the first among the first cohort in the industry to be reporting under CSRD in 2026 on 2025 numbers, and we've already commenced our project to prepare for CSRD. The greater transparency and detailed disclosures required under CSRD enable investors to compare companies and make investment decisions based on their ESG credentials. We have published three sustainability reports now, and certain elements of those link really well as we move to CSRD reporting Our sustainability reports are based on the GRI standards, the same disclosure framework that underpins CSRD, and have a materiality assessment, so some of the foundations are already in place.

Rather than differentiating aircraft lessors, it will probably bring us all similarly to a much greater level of disclosure for all, and any gaps that may exist will be closed. It raises everybody up rather than make anybody stand out. The smaller lessors will start reporting in subsequent years and their disclosure requirements will increase as well.

11. Insights from academia: Aviation and Aerospace Sustainability at Embry-Riddle Aeronautical

Dr. Tamilla Curtis

Dr. Tamilla Curtis, *Professor of Management at the College of Business of Embry-Riddle Aeronautical University, Embry-Riddle Aeronautical University, Daytona Beach Campus, USA, provides an introduction to its newly-launched graduate course in Aviation and Aerospace Sustainability. This addition, the university argues, goes beyond simply expanding the curriculum and is a proactive leap towards solving the aviation industry's most urgent challenges.*

Sustainability is no longer an option for aviation industry stakeholders; it is a necessity. With world population growth, aviation continues to expand its services, significantly contributing to trade, economic development, connectivity, and nations' overall prosperity. Airlines and airports have set ambitious targets to achieve net-zero greenhouse gas emissions through various initiatives, including the transition to sustainable aviation fuels, carbon offsetting, fleet modernization, collaboration, innovation, and other measures. These strategies are aimed at decarbonizing the industry and mitigating the environmental impact of the growth in air travel. Standards for these targets include pathways in line with the Paris Agreement, or the Science Based Targets Initiative (SBTi) which provides science-backed guidance to help companies reach net-zero by 2050.

However, there is a shortage of specialists with the advanced knowledge, skills, and expertise in the field of aviation and aerospace sustainability needed to implement these strategies and reach these targets. This need was identified at David B. O'Maley College of Business at the Daytona Beach campus, Embry-Riddle Aeronautical University, a premier higher education institution in Florida specializing in aviation and aerospace education and research.

The design of the course

Following discussions with the university and college leadership, aviation industry professionals, students, and alumni in Fall 2022, I proposed a new graduate course to bridge the industry labor gap in sustainable development. Since aviation cannot be viewed in isolation, I aimed not only to provide students with knowledge on the challenges and opportunities that the aviation industry is currently facing but also to provide a broader discussion on climate change, including the United Nations Framework Convention on Climate Change, the Paris Agreement, Nationally Determined Contributions, and other essential plans, protocols, and agreements. The ultimate goal was to equip students with the necessary skills and knowledge to contribute towards the development and implementation of a global framework for sustainable aviation, addressing the pressing need for specialized experts in this field.

Several grants were crucial in developing the course, including the David B. O'Maley College of Business professional development grant, the David B. O' Maley College of Business Faculty Fellowship, and the Center for Teaching and Learning Course Design Program grant. Those funds were used for professional development to expand my knowledge of aviation and aerospace sustainability. This resulted in IATA environmental sustainability training, attending aviation sustainability conferences, and supporting our students for the IATA Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA) certification. Overall, the development of our course serves as a compelling example of the need for substantial and targeted funding to effectively address the industry's labor gap.

The course is launched

After a year-long development, the experimental course "Sustainability, Environment, Society, and Governance in Aviation and Aerospace" was launched in the Spring of 2024. This course was initially open to master-level business students but will be expanded to engineering, aviation, and other graduate degree program students in the future. The enrolled students were from diverse backgrounds, including Sweden, Norway, South Korea, Thailand, Qatar, Canada, and the United States. This international mix fostered rich discussions on the topic of sustainable aviation practices and environmental plans in the students' home countries, enhancing the global perspective of the course.

The positive reception at the course's launch further highlighted the growing awareness among young people from different regions about the importance of sustainable aviation. The course introduced students to the main concepts and practices in aviation sustainable development. It went beyond theoretical discussions, providing practical applications of the ESG framework; assessing current and future technologies, carbon offsetting, aviation, and aerospace sustainability strategies; understanding the role of public policies and international organizations; and recognizing different stakeholders' perceptions toward aviation sustainability. To further enhance students' understanding, several guest speakers participated in the course, including representatives from the Boeing's Sustainable Aviation Fuel Aircraft Compatibility team, Munch Airport NJ LLC, and Lufthansa German Airlines, who shared their real-world experiences and insights.

Throughout the semester, students calculated essential metrics for and freight. Their semester-long project provided in-depth research for addressing climate change and environmental sustainability in the aviation sector and was divided into three parts. The first part provided a structured approach to address climate change, national environmental plans, and the global civil aviation commitment to net-zero emissions by 2050, including analysis and strategic proposals for reducing aviation's environmental impact. The second part involved evaluating the roles of airlines and airports in transitioning to sustainable transportation, including case studies on successful practices and the challenges faced. The final part explored advanced technologies and practices in sustainable aviation, assessing their potential impact and discussing the need for stakeholder collaboration, stronger regulatory frameworks, and international cooperation to reduce aviation emissions.

Positive feedback from students

The success of this course, bolstered by the support of the university and college leadership, underscores the importance of educating future generations of professionals who will lead the aviation industry's transformation towards sustainable development. Students have completed the course equipped with a specialized toolkit and a readiness to enact change, as reflected in their testimonials. One student expressed, "I am very excited to be entering the workforce at such a pivotal time for aviation, and to be able to apply all of the knowledge from this class towards a bigger purpose!" Another student echoed this sentiment, stating "[this course] has empowered me with the knowledge and tools necessary to actively contribute to and drive positive change within aviation". Overall, higher level education programs should aim to similarly prioritize the teaching of sustainable aviation theories, preparing graduates to become agents of positive change.

Get in touch

We are actively seeking opportunities to collaborate with higher education institutions, companies and other organizations dedicated to aviation sustainability to enrich our students' experience and further shape the curriculum of our new course. Collaborations might include guest lectures, internship placements, research partnerships, or project sponsorships.
If you are an industry professional or academic with expertise in sustainable aviation, ESG frameworks or other related fields, and you are willing to share your insights and expertise with our students, please contact Dr. Tamilla Curtis at curtist@erau.edu.

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 five 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.

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