Case Study
The ambition and uncertainties of the aviation net-zero transition plan challenge the financial sector

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EXECUTIVE SUMMARY

The aviation sector is confronted with the urgent task of reducing its GHG emissions and aligning with net-zero targets by 2050, all while forecasting a doubling of traffic. This case study delves into the complexities and obstacles faced in the aviation industry's journey towards decarbonization. The ICAO1 and the ATAG1 have set a target of zero GHG emissions growth for the international civil aviation sector since 2019, putting the spotlight on innovation, SAF2, and offset mechanisms. Nonetheless, doubts persist about the feasibility of these ambitious goals.

Main challenges:

- **Insufficient production of SAF**: The industry's reliance on green fuels surpasses the current volume available. Biomass competition among sectors restricts contributions to biofuels, and high costs introduce additional obstacles. In 2022, around 240,000 tonnes were produced, whereas the total production capacity in 2050 is projected to reach approximately 450 Mtoe against a 2050 goal of 4,800 Mtoe (with a 30% consumption reduction due to enhanced efficiency).
- Uncertain availability of green technologies: Technological innovations, like electric and hydrogen propulsion, hold the potential for emission reductions. However, translating these advancements into practical applications encounters significant challenges and uncertainties, especially regarding the timeline for industrial-scale implementation. Most commissioning announcements pertain to individual players rather than sector-wide adoption (the transition plan refrains from mandating a technology still in the R&D phase for all companies but instead suggests potential avenues to explore).
  - Commissioning of engines using 100% SAF: 2030-35
  - Airbus has revealed the development of a hydrogen aircraft by 2035
  - Global fleet transition to hybrid/electric aircraft and innovative architectures from 2035-40 (scenario 1)
- **Reliance on carbon offsets smaller than anticipated**: The industry heavily depends on carbon offset mechanisms like CORSIA to compensate for unavoidable emissions (between 6 and 76% of the efforts). The mandatory phase for all airlines worldwide commences in 2027. However, the efficacy and environmental integrity of these offsets remain subject to debate, primarily due to the loss of natural sequestration capacities across various regions worldwide.

Key Recommendations:

- **Clarify sustainability criteria for aviation sustainable fuels**: Public authorities should establish sustainability criteria for SAFs, considering the emission reduction levels across the fuel's entire life cycle. This would offer clear guidance to investors and simplify the identification of investment opportunities within this expanding field.
- **Provide venture capital to foster innovation and SAF production facility investment**: Given the substantial required investments and the urgency to replace kerosene, financial institutions could supply venture capital for constructing sustainable fuel production facilities and new infrastructure. Airlines could also commit to purchasing sustainable fuels at predefined prices or price differentials compared to traditional kerosene, thereby eliminating market risks for fuel suppliers, price volatility risks for applicants, and transition risks for investors.

- **Adapt depreciation rules**: Swift decisions are essential to mitigate the economic impact of deviating from the traditional asset depreciation rhythm. Policymakers could create incentives for SAF production by reallocating aviation taxes to fund decarbonization, thereby narrowing the remaining cost gap between conventional oil and sustainable fuels.
- **Harmonize regulations**: Ensure convergence between global programs (such as CORSIA) and regional initiatives like EU-ETS, minimizing competition distortions and maximizing emissions reductions. Extend carbon quota systems to encompass global domestic flights.
- **Improve transparency and carbon offsetting quality**: Establish robust criteria for carbon offset credits, preventing double counting and preserving environmental integrity. Consider governmental regulations and price floors to prevent subpar quality credits from undermining emissions reduction endeavors.
- **Strengthen international collaboration**: Foster partnerships and knowledge exchange among stakeholders, leveraging collective efforts to accelerate the adoption of sustainable practices in aviation and transportation at large.

The aviation sector faces significant challenges in attaining its net-zero emissions goal while accommodating traffic growth. Innovations in green fuels, technological advancements, and effective carbon offset mechanisms are pivotal, necessitating considerable investment, regulatory alignment, and collaboration. Government support, transparent sustainability criteria, and enhanced financial incentives are vital to achieving a sustainable and decarbonized aviation industry.

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Climate change poses an almost existential threat to commercial aviation. With current emissions around 900 $MtCO_2eq$/year, the civil aviation industry is committed to reducing its emissions and aligning itself with Net-zero objectives by 2050 while doubling its traffic.

On the road to Net-zero, the aviation industry is showing itself to be **dependent** on **green fuels**, for which the volume produced is largely insufficient, and on future technological innovations. To achieve zero net emissions, the industry also intends, to a lesser extent, to make massive use of "credit offsets", the reality and effectiveness of which are open to debate. This objective is still possible according to the assumptions of the International Civil Aviation Organization (ICAO), but not everyone is convinced the target is achievable – a recent poll of industry executives by GE Aerospace found that 32% doubt it can be reached. This case study is inspired by a Montaigne Institute paper[1].

1. Challenging ambitious aviation decarbonation plans in the face of doubled traffic by 2050

In 2020, the ICAO and the ATAG (Air Transport Action Group), representing the global aviation industry, set a target of zero growth in GHG emissions for the international civil aviation sector to align with the Paris Agreement.

To achieve this, airlines must commit to lowering their emissions by implementing innovation and technical/operational improvements, accessing sustainable aviation fuels (SAF) in accordance with the recommendations of the **LTAG** (Long-Term Aviation Goals) reports, and offsetting remaining incompressible emissions. This offsetting involves purchasing carbon credits through the CORSIA scheme to compensate for emissions exceeding the 2020 level.

Depending on the transition scenario analyzed by the ICAO and ATAG, the contribution to decarbonization from these various levers differs significantly.
The ICAO promotes the "Scenario 3 WayPoint 2050" (Annex 1), which primarily focuses on reducing carbon emissions through the use of **sustainable aviation fuels (SAF) (53%), technology innovation (34%), operational and infrastructure optimization (7%), and offsetting mechanisms and carbon capture (6%).**

Another scenario, the "Scenario 0 Waypoint 2050 low SAF", places greater emphasis **on offsetting (76%), with technology innovation (10%), operational and infrastructure optimization (9%), and SAF (5%)** making more modest contributions.
These simulations reveal that, while challenging, achieving the net-zero pathway for the aviation sector heavily relies on important innovation breakthroughs and widespread access to sustainable aviation fuels, as carbon offsetting alone may not suffice.

1. https://www.institutmontaigne.org/ressources/pdfs/publications/aviation-decarbonee-embarquement-immediat-rapport.pdf#page=52

2. The necessity to unleash innovation though actual formidable obstacles

2.1 Multiple innovation opportunities

Aviation's transition ambitions are marked by their boldness in terms of innovation. The simulations are based on the CAEP[2] Task Force on the Feasibility of a Long-Term Ambitious Target (LTAG-TG) to Reduce CO_2 Emissions from International Civil Aviation[3], which developed three integrated sector scenarios. Each scenario is built upon a subset of technology, fuel, and operational scenarios, representing a wide range of readiness states and delivery capabilities. It's evident that the different scenarios present varying strategies concerning technologies based on anticipation. However, they all may encounter significant challenges in translating these advancements into reality, leading them to often be considered unrealistic.

Innovation, as considered by the LTAG report, includes:

- Implementing technical and technological innovations in aircraft engines and structures. This entails (hybrid) electric propulsion and hydrogen propulsion, along with accelerating the incremental reduction in aircraft fuel consumption. Facilitating the financing of fleet renewal (every 15 to 20 years) as new technologies emerge is essential for these innovations. This could be achieved through mechanisms such as taxonomy or accelerated depreciation.
- Enhancing performance in all transportation phases, including ground operations and air traffic management. Unconventional measures like formation flights and introducing intermodality for the start/end of journeys (connecting main rail stations to terminals for easier transitions) are considered.
- The primary lever for decarbonization remains the replacement of fossil fuels with sustainable aviation fuels (SAF). These include biofuels based on biomass, waste, low-carbon aviation fuels (LCAF), and e-fuels produced from electricity, water, and CO2 (synthetic electrofuels, or PtL for Power-to-Liquid).

By 2050, the ICAO aims for a 55% reduction in fuel emissions in Scenario 3 WayPoint 2050. Given that operational costs make up 20% to 40% of airline expenses, replacing conventional kerosene-based fuels (derived from high-emission petroleum) is imperative, especially since it's the most effective lever for emission reduction. New fuels, along with associated technical innovations in fuel efficiency, have the potential to reduce climate impact by up to 50% by replacing fossil kerosene, which is encouraging.

According to CAEP, innovation in aircraft technology could lead to a 21% reduction in CO_2 emissions by 2050, provided we take action promptly. However, caution should be exercised when interpreting absolute CO_2 emission levels in various reports due to modelling assumptions[4]. Hydrogen-powered aircraft might exhibit lower in-flight fuel efficiency compared to aircraft using interchangeable fuels. The extent of CO_2 emission reductions depends on the lifecycle of the hydrogen used, and the production of interchangeable fuels may be less energy-efficient than the production of liquid hydrogen on a lifecycle basis.

Ultimately, while integrated scenarios demonstrate the potential for a substantial reduction in CO2 emissions, none of them predict zero CO2 emissions through sector-specific measures, even with a 100% replacement of conventional jet fuels by SAF. This underscores the vital role of carbon offsetting in the Net-zero plan without significantly reducing flight levels.

2.2 Uncertain SAF availability

While the aviation sector relies on sustainable aviation fuels (SAF), several physical, technological, and economic barriers on the production side will likely prevent biofuels from surpassing conventional kerosene by 2050, as indicated by the ICCT.

Each mode of transportation follows a distinct and varying trajectory towards advanced decarbonization, featuring a specific level of penetration of substitution technologies. However, there exists a shared need for biofuels across transportation modes to mitigate the environmental impact associated with high petroleum product consumption.

Furthermore, the energy demand is closely linked to the evolution of total transport traffic. A decrease in traffic of around 30% compared to the projected 2050 levels could lead to a reduction of approximately 40% in the requirement for carbon-free energy. Conversely, a traffic increase of about 30% would necessitate a 35% energy increase.

2. CAEP : a group of researchers dealing with technical issues related to the implementation of the Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA), including the maintenance of the Standards and Recommended Practices (SARPs) contained in the Convention on International Civil Aviation and related guidance.

3. This report is based on 3 integrated scenarios developed for the LTAG, considering "readiness, achievability and ambition" (See Annex 1).

4. *e.g.*, aircraft continue to enter the fleet, but their technology is frozen at 2050 levels (no further technological improvements after 2050, resulting in higher than expected CO_2 emissions after 2050).

Expected exploding investments and operating costs of innovation:

ICAO stressed that a lot of investment and funding would be needed to promote the achievement of the plan.

Concerning Investment needs between 2020-2050, according to ICAO for the Integrated scenario 2 :

- **Technology : Needed investment range $ 335-1830 B**
- **Operations : Needed investment $ 97 B**
- **Fuels : Needed investment $ 2305 B +** 2,705 trillion of incremental costs to airlines

See annex 3 for costs and investments details of Waypoint integrated scenario 2 (medium ambition and medium level of traffic forecast).

Low speculative savings

Faced with the colossal investments required, the quantified gains to date seem relatively low. According to the ICAO Integrated Scenario 2, investments in the different categories would:

- Technology: reduced operator fuel costs: ≈ $ 740 B
- Operations: - reduced operator fuel costs: ≈ $ 300 B

The decarbonization of air transport is integral to a global energy transition, entailing the large-scale production of decarbonized energy to replace fossil fuels. Oil, being a high-carbon energy source, is extensively used in transportation, as well as for petrochemicals and heating. The global consumption of petroleum-derived fuels (gasoline, diesel, kerosene, heavy fuel oil, etc.) was approximately 2,600 Mtoe in 2018 and could potentially reach 4,800 Mtoe by 2050, according to the Montaigne Institute.

Hence, while the available sustainable biomass might be sufficient for the aviation sector alone, this adequacy diminishes when considering all sectors collectively. Biomass availability will face competition between sectors, thus limiting the contribution of biofuels to aviation's alternative fuel supply. These physical limitations introduce elevated risks, rendering sector planning particularly uncertain, especially in cases of similar needs among sectors.

2.3 The cost of biofuels raises an additional concern

Currently, biofuels cost 2 to 5 times more than fossil kerosene. Even in industrial production, biofuels are expected to remain the most expensive option, unless influenced by carbon tax or other financial mechanisms that might favor e-fuels if carbon prices remain at their current levels.

2.3 Rolling out certain new technologies requires almost a revolution

The results of current technological innovations are still highly speculative, as they are generally still in the R&D phase. Meanwhile, the aviation industry has set targets for 2050, which is less than 30 years from now, and the level of investment needed to industrialize such innovations is colossal.

In the case of hydrogen, the current results appear promising, with a potential reduction in the carbon footprint of up to -65% according to Carbon4, including non-CO_2 effects. However, even in its condensed form, hydrogen takes up three times more space than paraffin, necessitating larger tanks. Additionally, it comes with greater safety constraints compared to kerosene.

As a result, hydrogen requires changes to the entire airport ecosystem, including hydrogen production, storage, and aircraft refueling. This implication carries a particularly high cost, coupled with a significant level of risk for investors[5]. Furthermore, historical precedent demonstrates that it can take between 20 and almost 70 years for new energy technologies to progress from the initial prototype to materialization, which means reaching 1% of a national market (Gross, 2018; Bento, Wilson, and Anadon, 2018).

5. Airbus recently announced its intention to develop a hydrogen-powered single-aisle aircraft that would enter service in 2035 and cover a radius of 1,500 km. Longer-range aircraft would have to wait until 2045. And even with a great deal of political will, it will take time for these breakthrough technologies to spread and have a significant impact on the world fleet, even though the industry has set targets for 2050. ICCT estimates that hydrogen could contribute between 6% and 12% to the decarbonization of aviation by 2050, due to the slow implementation of changes, and even IATA considers that it should only represent 10% of the fuel used by that date.

3. The controversial path of carbon offsets in the aviation's quest for net-zero

CORSIA system

CORSIA, the world's first market-based offsetting scheme, offers a harmonized means of offsetting emissions for the international aviation sector, which constitutes more than 60% of global traffic. The scheme aims to minimize market distortions while considering the specific circumstances of ICAO Member States.

The CORSIA scheme offsets the volume of CO_2 emissions that cannot be reduced through technological improvements, operational enhancements, and sustainable aviation fuels. It achieves this by using emissions units from the carbon market.

Starting from January 1, 2019, all aircraft operators, including large passenger airlines, cargo airlines, business aviation, and private aviation, with emissions exceeding 10,000 tons of CO_2, are required to annually report their emissions to their respective national authorities. These authorities then determine the number of offset credits needed for each airline.

To alleviate administrative burdens on operators with low activity levels and offset requirements, an offset threshold of 3,000 tons of CO_2 over a three-year compliance period has been agreed upon.

Certain situations, such as island countries and least developed countries, are excluded from the scope of application.

By January 1, 2024, the mechanism will include 120 companies. The year 2021 marks the commencement of using all CORSIA-eligible emission units during the first phase. Refer to Annex 4 for a list of entities whose programs are eligible to supply emission units to CORSIA during its initial phase.

The analysis period has been extended to 2070 to observe the effects of new technologies that will enter the fleet by 2050. In order to incentivize innovation when technological and technical improvements are not available in the year following their introduction, the CORSIA mechanism can rely on 75% of the associated efforts of "decarbonization". This further fuels the debate over offsetting choices.

CORSIA v.s EU-ETS
Insufficient convergence and remaining competition challenges in the global aviation's battle for carbon neutrality

Two major carbon quota systems will now coexist: the EU-ETS (European scale) and CORSIA (global scale). While they differ in terms of geographical coverage, approach, applicability, and the objective of limiting CO_2 emissions from the aviation sector is comparable, albeit with the EU-ETS being stricter. It is essential that the coexistence of these systems does not distort competition, eventually leading to convergence towards a carbon-neutral objective, and encompassing all commercial international flights (*see Annex 6*).

The EU-ETS operates as a cap-and-trade system, where covered sectors like air transport must not exceed their authorized emissions cap. To achieve the goal of reducing emissions by 55% between 1990 and 2030, the EU is currently in the process of reducing the cap. This action is intended to send a strong price signal, incentivizing emission reductions and discontinuing the issuance of free allowances.

CORSIA, on the other hand, is a compensation system without a cap on the total CO_2 emissions. Airlines are required to offset their emissions against 2019 levels (which are considerably higher than those of 1990). Therefore, the system aims to achieve carbon-neutral growth from 2019 (not from 1990 as the EU is aiming for by 2050). Implementation of CORSIA is expected to take time, with potentially extended 5-year test phases, all while the climate emergency persists. The system only covers a limited scope of emissions and partly relies on carbon offsetting, which does not effectively reduce emissions.

This asymmetry of ambition presents several limitations. Firstly, due to the EU-ETS's higher ambition, it could lead to higher costs, potentially impacting the profitability of EU airlines or directly.../...

…/… influencing ticket prices. This could affect demand and create significant competition distortions, especially for journeys involving stopovers within or outside the EU. Secondly, this coexistence implies sub-optimal emission reductions, particularly if technological innovation and sufficient sustainable aviation fuels (SAF) are not forthcoming.

According to a 2021 EU study obtained by Transport & Environment, regulating EU airline pollution solely through CORSIA is the least favorable option. This choice is linked to the largest net increase in global aviation CO2 emissions. If CORSIA replaces existing EU climate regulations, it "risks undermining the ability to reach net-zero emissions by mid-century".

In contrast, the Council and the European Parliament have reached a provisional political agreement on revising the EU-ETS rules applicable to the aviation sector. Under this agreement, the EU-ETS will cover intra-European flights, including flights to the UK and Switzerland. CORSIA will apply to extra-European flights to and from third countries participating in CORSIA from 2022 to 2027, ensuring aviation contributes to the EU's emission reduction targets under the Paris Agreement.

The co-legislators have agreed to phase out free EU-ETS emission allowances for the aviation sector as follows: 25% in 2024, 50% in 2025, and 100% from 2026. In other words, allowances will be fully auctioned from 2026 onwards. Regarding revenue utilization, the co-legislators agreed to transfer 5 million allowances from the aviation sector to the Innovation Fund. Additionally, the Council and Parliament allocated 20 million free allowances to promote the use of SAF.

Notably, domestic flights in non-European countries, currently constituting nearly a third of global air traffic, are not covered by either scheme. This notably applies to countries like China (2nd largest domestic market in CO2 emissions in 2019), India (3rd), and Brazil (6th).

Given the expected increase in traffic levels in these dynamic regions, especially in Asia, extending these carbon quota systems to domestic flights outside of Europe will become necessary to address air traffic emissions as effectively as possible.

4. Why the carbon offset based CORSIA Mecanism "risks undermining the ability to reach net-zero emissions by mid-century" according to the ONG transport & environment

Planting trees and allowing them to grow to capture CO_2 can cost between $ 3 and $ 10 per metric tonne of CO_2 captured, without significantly reducing the carbon footprint. This translates to a ticket price increase of less than a dollar per passenger on a short-haul flight, providing a low incentive to reduce flight frequency.

While fifty percent of airline companies have made substantial offsetting commitments that exceed CORSIA requirements, and they offer customers the option to cover offset costs themselves, according to a McKinsey survey, fewer than 1% of customers use this system.

An oversupply of carbon offsets currently exists due to weakened CORSIA rules resulting from industry lobbying last year, resulting in three times more supply than demand.

Currently, it remains unclear how the commitments and mechanisms of the Paris Agreement will interact with the voluntary carbon market. However, they pose a potential challenge to CORSIA's carbon credit supply. Nevertheless, CORSIA is anticipated to generate a demand for approximately 1.6 billion carbon credits during its current lifespan, and the private sector is already witnessing a surge in offset credit demand as companies pursue carbon neutrality goals and ESG objectives[6].

The capacity to provide high-quality credited emission reductions may diminish under pressure from various sectors. Carbon offsetting companies might be tempted to issue more credits to satisfy demand at low prices, potentially compromising quality (*e.g.*, deforestation concerns). Without public regulations (such as price floors), this carbon offset mechanism could significantly limit emissions reduction efforts achieved through technological innovation.

Additionally, a study by the Publication Office of the European Union highlighted that accepting credits from existing projects in CORSIA's first and second phases poses a risk of double-counting emissions reductions toward both CORSIA and the project

6. The ICAO estimated the costs from CORSIA offsetting, assuming carbon prices range from a low of $ 6 to $ 12, to a high of $ 20 to $40, per metric ton of CO_2.

Carbon capture/Sequestration

Carbon capture is currently a topic of significant controversy for multiple reasons. Carbon sequestration serves as a means to attribute responsibility for human emissions to nature. There are two options for carbon sequestration:

- **Firstly, natural sequestration occurs in soils, forests, peatlands, and oceanic carbon sinks. However, these sinks are no longer adequate to absorb human CO_2 emissions. This phenomenon is predicted to worsen due to climate change. Factors like drought followed by torrential rain, forest fires triggered by drought, rising temperatures, and pest epidemics are all set to increase. A study published in Science last September already indicated that calculations of carbon storage by forests were "excessively optimistic", given that many forests are losing their carbon-sequestering capacity.**
- **Secondly, mechanical sequestration involves capturing carbon dioxide in boilers or gas turbines, compressing it, and transporting it to a landfill site for massive and secure underground burial. However, since CO_2 emissions from transportation and housing are too diffuse to be captured and stored, aviation relies on natural carbon capture.**

host country's NDC targets. The evaluation of credit quality is crucial, and ICAO has established eligibility and integrity criteria. However, inconsistency in applying these criteria is evident, with no program fully meeting all requirements. Concerns arise regarding safeguards, sustainable development, additionality, and the lack of provisions to prevent double counting. These doubts cast uncertainty on the environmental integrity of using these credits to offset aviation emissions in CORSIA's Pilot Phase.

5. Political imperatives in aviation's decarbonization journey: navigating (turbulent waters) towards sustainability

5.1 Low emissions fuels require further common efforts and clarifications

The institution also recommends developing the obligation to incorporate SAF in all geographical areas, similar to what has been initiated in Europe with Refuel.

Regional differences are anticipated in the implementation of operational measures, with the most significant disparities likely to emerge in the production and adoption of fuels. This takes into consideration the regional availability of biomass and hydrogen, renewable energy sources, as well as market dynamics and infrastructure. Current planning does not account for these variations (Annex 5).

In an interconnected-sector economy, innovations in low-emission fuels could benefit the entire transport industry. Furthermore, biofuels could benefit from various sector investments.

To address the challenges financiers face in integrating substantial investments in developing technologies and fuels, often characterized by uncertain profitability rates, the Institut Montaigne recommends that public authorities clarify the definition of SAF. This can be accomplished by introducing sustainability criteria for SAF that are universally shared by all countries worldwide, as defined by the ICAO. These criteria would encompass the type of raw materials used and the level of emissions reduction throughout the fuel's life cycle.

This recommendation also advises the EU to encompass hydrogen in the definition of SAFs. This move would facilitate the development of all sectors contributing to the decarbonization of air transport. Hydrogen, as a fuel, requires even more significant investment than other SAFs, as it currently entails changing the engines in existing aircraft without waiting for these assets to depreciate. To unlock various investments associated with this energy, providing producers and investors with visibility is necessary. The EU should take a leading role in SAF production.

5.2 Swift adoption of emerging technologies necessitates adjusting depreciation rules and providing investment incentives

The amount simulated by the plan appears achievable only if proactive policies are established to offer project leaders visibility on demand. Governments hold a pivotal role in supporting the energy transition within the sector.

As the aviation industry must align its strategy with the Paris Agreement while managing its long-life assets, which can rapidly become obsolete, making decisions now is essential to mitigate the economic impact of disrupting the traditional depreciation cycle.

Secondly, to facilitate acceptance and optimize the utilization of necessary aviation taxes by industry players, policymakers at the national and regional levels could create incentives for FAS production. This can be achieved by setting appropriate targets and reallocating aviation taxes to finance decarbonization within the industry. This action would narrow the remaining cost gap between conventional oil and SAF.

Thirdly, given the anticipated investment amounts and the urgency to replace kerosene, financial institutions could provide risk capital for the construction of FAS production facilities and new infrastructure needed to achieve anticipated cost savings. Forming a coalition of airlines could amplify the required volume, thereby generating economies of scale and reducing competition distortion linked to asset write-offs. Airlines could also commit to purchasing SAF at a predetermined price or a price differential compared to traditional kerosene. This would eliminate market risks for fuel suppliers and mitigate price volatility risks for demanders.

6. Political drivers of aviation sustainability: several unilateral regulations and bold targets to lead the way

Unilateral regulations linked to this internationally ambitious transition plan are emerging (Annex 8 provides current worldwide policies on aviation fuels).

In July 2021, the European Commission released a legislative package called Fit for 55. One component of this package, ReFuelEU, aims to stimulate the production and utilization of FAS. It is crucial to support the supply of SAF to establish a competitive market in Europe and ensure that SAFs are used to attain emission reduction goals, minimizing competition distortions.
The EU proposal mandates suppliers to ensure that all aviation fuel supplied to aircraft operators at European Union (EU) airports contains a minimum proportion of SAF. This mandate is set to commence in 2025, with a minimum FAS volume of 2%. This volume will increase in five-year intervals, reaching a minimum of 63% in 2050.

In the US since 2019, SAF has been recognized as eligible fuel for generating credits, such as a fuel tax credit or a credit in the form of a general business credit. These credits can incentivize SAF production, as they can be sold to other obligated parties under the obligation. From 2021, the credit will range from USD 1.50 to USD 2 per gallon for blenders that provide SAFs with a demonstrated lifecycle GHG reduction of 50% or more and ICAO eligibility[7].
In 2021, the US also announced a new sustainable aviation fuel goal, aiming to increase SAF production to at least 3 billion gallons per year by 2030. Additionally, a $1 billion grant over five years was planned to enhance the number of SAF production facilities. A proposed SAF tax credit is intended to reduce costs and expedite domestic SAF production.

New actions include:

- A proposed SAF tax credit aiming to reduce costs and rapidly scale domestic SAF production.
  Norway has mandated that 30% of aviation fuel used in the country must be sustainable by 2030, and all short-haul flights must be 100% electric by 2040.
  Canada has introduced a carbon tax of approximately $ 21 per metric tonne of CO2.

In conclusion, this case study leads us to various lines of thought. Eamonn Brennan, Director General of Eurocontrol, stated, "We expect the number of flights to grow by 44% between now and 2050, taking us up to 16 million a year – compared to 11 million in 2019. Our report shows that we can achieve net zero by 2050 with a series of tangible measures requiring coordinated action by aircraft manufacturers, airlines, airports, fuel companies, ANSPs, and, crucially, governments and regulators". Therefore, is it politically reasonable to double traffic as planned?

James Mitchell, director at the Center for Climate-Aligned Finance, emphasizes that "collaboration is key to meeting climate commitments and to decarbonizing the hard-to-abate sectors". Indeed, every financial institution must determine its acceptable risk level in relation to greening its portfolio and increasing collaboration with partners in technological breakthroughs or complete business model overhauls. Hence, is this sectoral approach adequate to meet the sector's decarbonization goals compared to a widespread adoption of the SBTi approach by all sector players, and/or an ambitious transition plan within the transport sector that could provide more visibility?
Moreover, do we possess adequate sectoral agreements to allocate sufficient biofuel production? How can we encourage more partnerships in the realm of SAF? Although SAF and aviation tax policies

7. There is also a supplemental credit of one cent for each percent that the reduction exceeds 50%.

continue to evolve, regional efforts remain insufficient according to IEA.

Do financial institutions possess the means to manage risks associated with these various developing technologies?

While debates and incentives exist regarding the incorporation of aviation in the sectors of the European green taxonomy, these discussions lead us to ask how to ascertain that a sector is genuinely undergoing transition while substantial technical and technological uncertainties remain, as is the case for aviation.

Are the financial incentives for decarbonization sufficient and optimized? Should we promote and regulate other complementary incentive tools? For example, could certain forms of transition debt financing, where borrowers receive discounts on their borrowings upon reducing CO2 per revenue per passenger kilometer over a set period (such as the life of the debt), be effective tools for encouraging emission reduction? The aviation finance market is adapting, but is it adapting quickly enough?

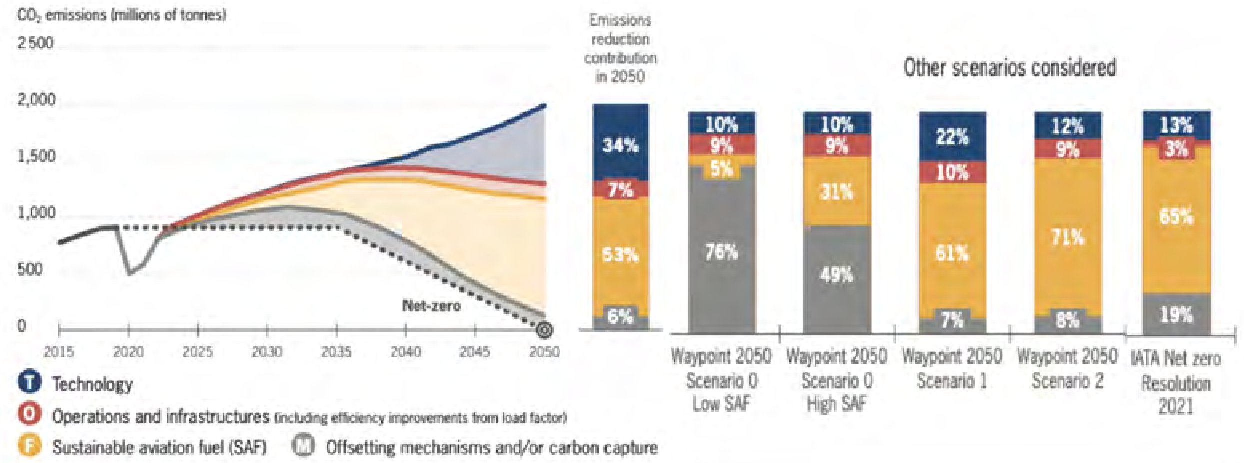
Should a special emphasis be placed on working groups like the collective Climate-Aligned Finance (CAF) framework, enabling financial institutions to assess the emissions of their aviation loan portfolios and collaborate with clients to report their emissions, fund lower-carbon solutions, and support investments in new technologies?

Do scientific authorities like the IPCC feel comfortable with the scale of carbon offsetting that this transition plan could involve (as well as that of other sectors)? In this context, do existing public policies prove sufficient and adequately ambitious? Would it be optimal to establish a maximum proportion of carbon offsetting on the total avoided emissions by the concerned entity/sector? How can public authorities encourage the issuance of high-quality carbon offset credits without undermining natural sequestration capabilities?

ANNEX 1

WORLD AIR TRANSPORT DECARBONIZATION SCENARIOS

Scenario 3 - Waypoint 2050 | Other scenarios considered



Based on Waypoint 2050, ATAG, IATA10, Fly Net Zero. Archery Strategy Consulting analysis.
Modified version from Institut Montaigne
Source: Waypoint 2050 p26, ATAG, IATA10, Fly Net Zero pp 5-8. Archery Strategy Consulting analysis.
https://aviationbenefits.org/media/167417/w2050_v2021_27sept_full.pdf

Methodology and scenarios; the different scenarios of WayPoint differ in the way they use the various levers for improvement:

- All scenarios are placed in the context of an Integrated Scenario 0 (IS0) which represents emissions reductions from fleet evolution based on aircraft technology frozen at 2018 levels and no further operational or fuel improvements[9]; whatever the level of FAS penetration envisaged (5% to 31%), achieving the objective of neutrality relies mainly on measures to capture CO2 or offset carbon emissions (49% to 76%);
- Integrated Scenario 1 (IS1) – "high readiness, high capability and low ambition". This nominal or low-level scenario represents current (2021) expectations of future technologies, operational efficiencies and fuel availability. It includes expected enabling policy factors favouring technology, operational and fuel investments and a low level of system change, in particular the absence of major infrastructure changes. Technological improvements are amplified with the integration of disruptive technologies (22%), in particular with the transition of the fleet to hybrid/electric aircraft and innovative architectures from 2035/40; the carbon neutrality objective is achieved through the use of large quantities of SAF (61%); Of the three scenarios, it requires the least effort to implement, although this effort is still considerable for some players.
- Integrated Scenario 2 (IS2) – "average readiness and ability to deliver and medium ambition". This enhanced or more ambitious scenario is roughly halfway between the other two scenarios – faster deployment of future technologies, greater operational efficiencies and greater fuel availability. Technological improvements include new aircraft configurations but no significant switch to electric or hybrid engines; the carbon neutrality objective is again achieved by using very large quantities of SAF (71%). The scenario assumes stronger policy drivers for investment in technology, operations and fuels and greater system change, *e.g.*, limited infrastructure changes.
- Integrated Scenario 3 (IS3) – "low readiness and capability and high ambition". This dynamic or high-ambition scenario represents the maximum possible effort in terms of future technology deployment, operational efficiencies and fuel availability. It assumes maximum political enablers for investment in technology, operations and fuels, and major change to the globally harmonised system, for example major and far-reaching changes to airport and energy infrastructure. Technological developments are more marked (34%), with electric aircraft with up to 100 seats (regional), zero-emission aircraft (fuelled by decarbonised hydrogen) for the 100-200 seat segment (short and medium-haul), and non-conventional aircraft with hybrid-electric propulsion for larger aircraft; SAFs continue to play a major role in achieving carbon neutrality in this scenario (53%). Of the three scenarios, this one requires the greatest implementation effort.

The LTAG's IS1 scenario would give 23 GtCO2 of residual cumulative emissions from international aviation from 2020 to 2050 and 23 GtCO2 from 2051 to 2070. The IS2 scenario would give emissions of 17 GtCO2 from international aviation from 2020 to 2050 and 11 GtCO2 from 2051 to 2070. The IS3 scenario gives emissions of 12 GtCO2 from international aviation from 2020 to 2050 and 4 GtCO2 from 2051 to 2070.

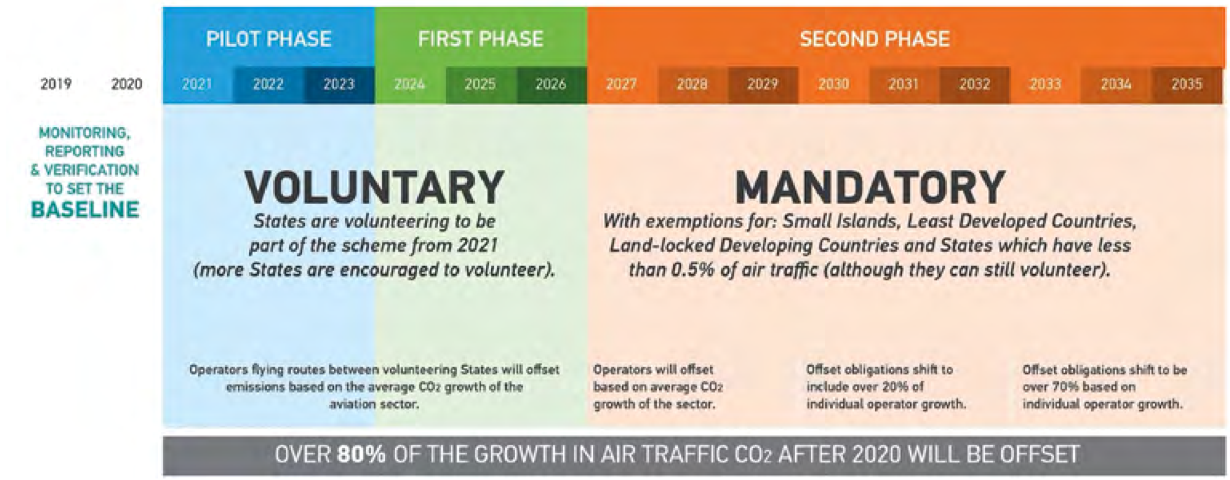
Source : LTAG report with comments from Institut Montaigne
https://www.institutmontaigne.org/ressources/pdfs/publications/report-decarbonizing-aviation-all-aboard.pdf#page=20

8. Recognising that its task is to assess the feasibility of possible future scenarios, the LTAG-TG has drawn on the tools and methodologies of the Forecasting and Economic Analysis Support Group (FESG) and the Modelling and Database Group (MDG) that were used to establish the trends in the CAEP trend analysis. In particular, it drew on the most recent trend analysis from the CAEP/12 cycle.

ANNEX 2

CORSIA phases

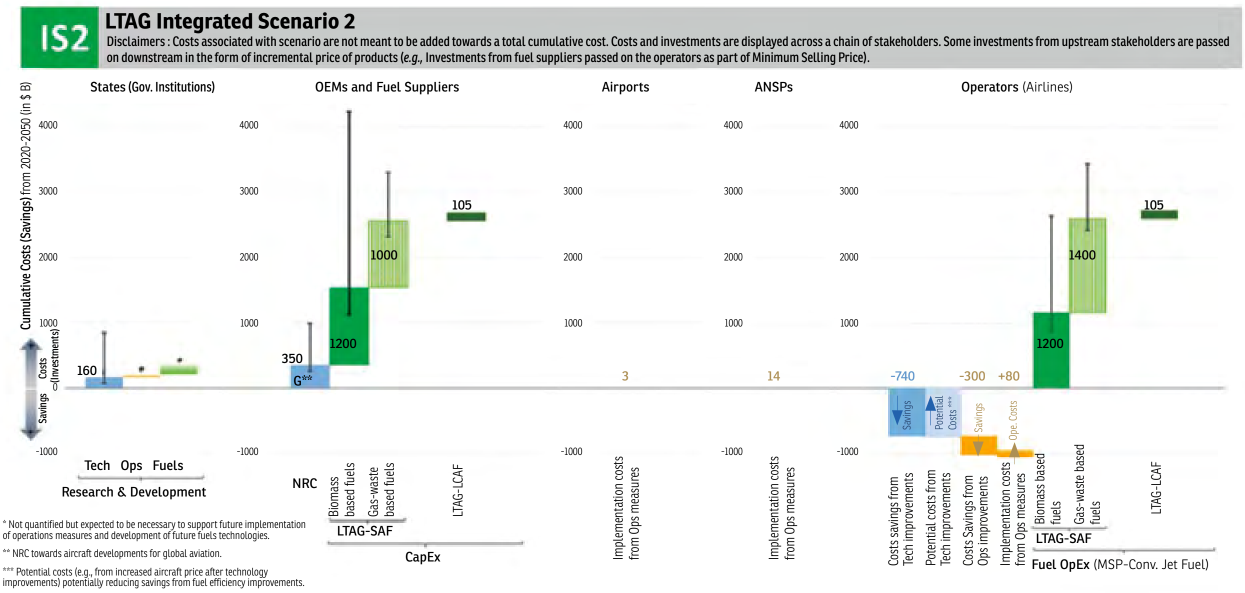
CORSIA is being implemented in three phases; for the first two phases (2021-2026), participation is voluntary. From 2027, participation will be determined on the basis of 2018 RTK data.



Source : Aviation Benefits

ANNEX 3

Costs and Investments details of Waypoint integrated scenario 2 (medium ambition)



Medium level of traffic forecast
For the 2 other scenarios and other level of traffic forecast : https://www.icao.int/environmental-protection/LTAG/Documents/ICAO_LTAG_Report_AppendixR1.pdf

ANNEX 4

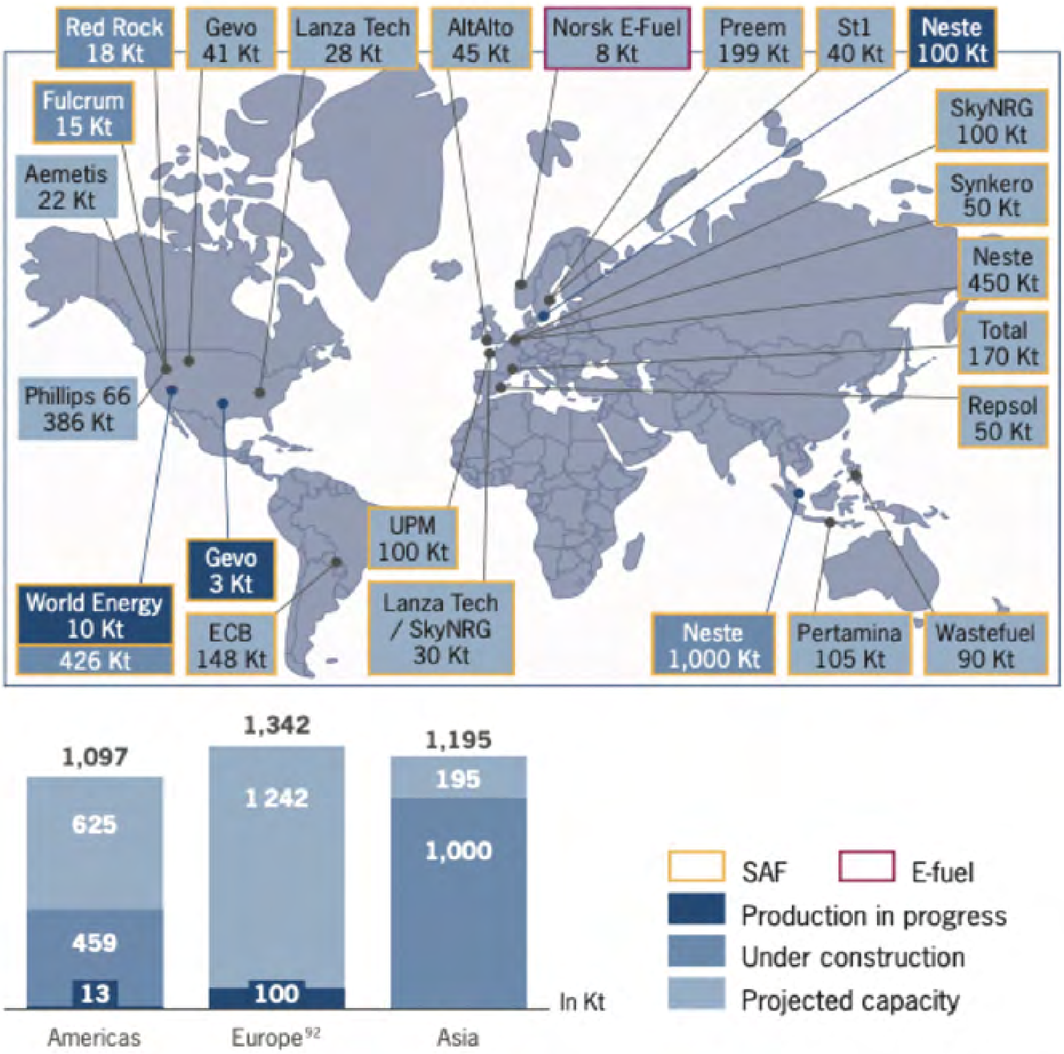
Entities whose programmes are eligible to supply emission units to CORSIA for its first phase are:

- American Carbon Registry;
- the Architecture for REDD+ Transactions;
- China's voluntary GHG emissions reduction programme;
- Clean Development Mechanism;
- Climate Action Reserve;
- The Gold Standard;
- Verified Carbon Standard.

Exept China's voluntary GHG emissions reduction programme, this is only North American organisations.

ANNEX 5

OVERVIEW OF INCENTIVES FOR SAF USE AROUND THE WORLD



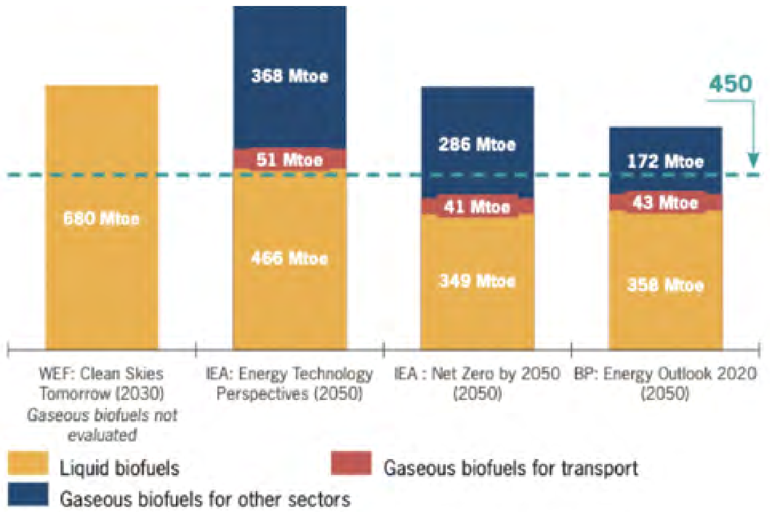
Source: SkyNRG – WDB Action Programme; Archry Strategy Consulting analysis

OVERVIEW OF INCENTIVES FOR SAF USE AROUND THE WORLD

	Traffic and emissions 2018			Ballistic trajectory 2050	
	Traffic 2018 (Bn passenger.Km or Bn T.Km)	Fuel consumption 2018 (Mtoe)	Of which biofuel	Traffic 2050 (Bn passenger.Km or Bn T.Km)	30% reduction in consumption (Mtoe)
Road transport for passengers	30	**1,200**	2,4%	71	2,000
Road transport for goods	22	**800**	3%	58	1,600
Air transport	8	**350**	0,1%	22	600
Shipping	85	**250**	0,1%	269	600
		2,600 Mtoe			**4,800 Mtoe**

Souce: ITF Transport Outlook 2019, Waypoint 2050, IEA, Archery Strategy Consulting Analysis
Notes : The column "30% of reduction in consumption (Mtoe)" considers the reduction in consumption (In megaton of oil equivalent) linked to technological change (improvement in yield) compared to a scenario by 2050 where technologies would not have gained in efficiency

ESTIMATED LIQUID BIOFUEL PRODUCTION IN 2030/2050 ACCORDING TO DIFFERNT PLAYERS



Source: IEA, Net Zero by 2050 & Energy TechnologyPerspectives; Clean Skies Tomorrow; BP, Energy Outlook 2020 Edtion; Archery Strategy Consulting Analysis

Incentives of SAF production around the world facing the prospected requirements in 2050

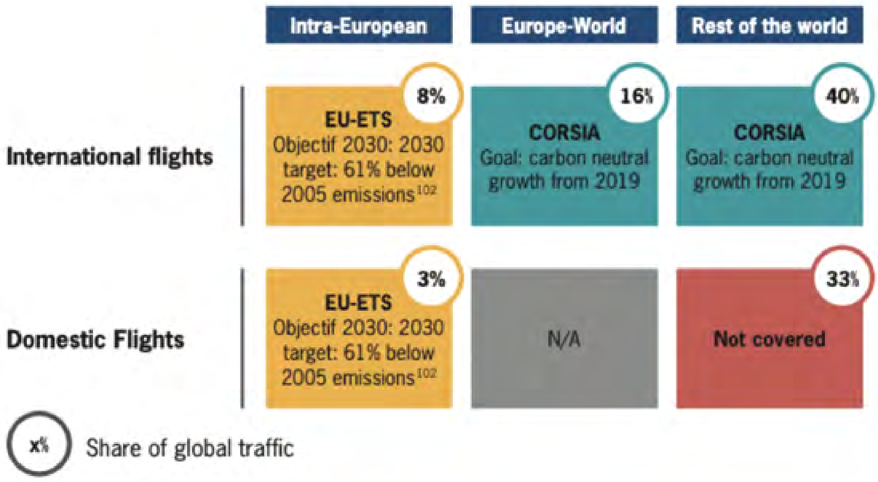
Total incentives for SAF reach around **450 Mtoe** and we will **need** (with a 30% reduction in consumption due to better efficiency) **4,800 Mtoe**. Global biofuel production in 2022 was around **300,000 tonnes**.

In order to secure the business plans of project developers, and therefore the development of new production capacity, SAF producers must be given visibility over long-term demand, so that they can invest in production facilities with confidence:

- in terms of **volume**, the mandatory incorporation of FAS guarantees significant and growing demand from airlines, thereby securing this dimension;
- In terms of **value**, there is considerable uncertainty over the expected price cuts for the various FAS, with a risk of losing competitiveness in the medium term.

ANNEX 6

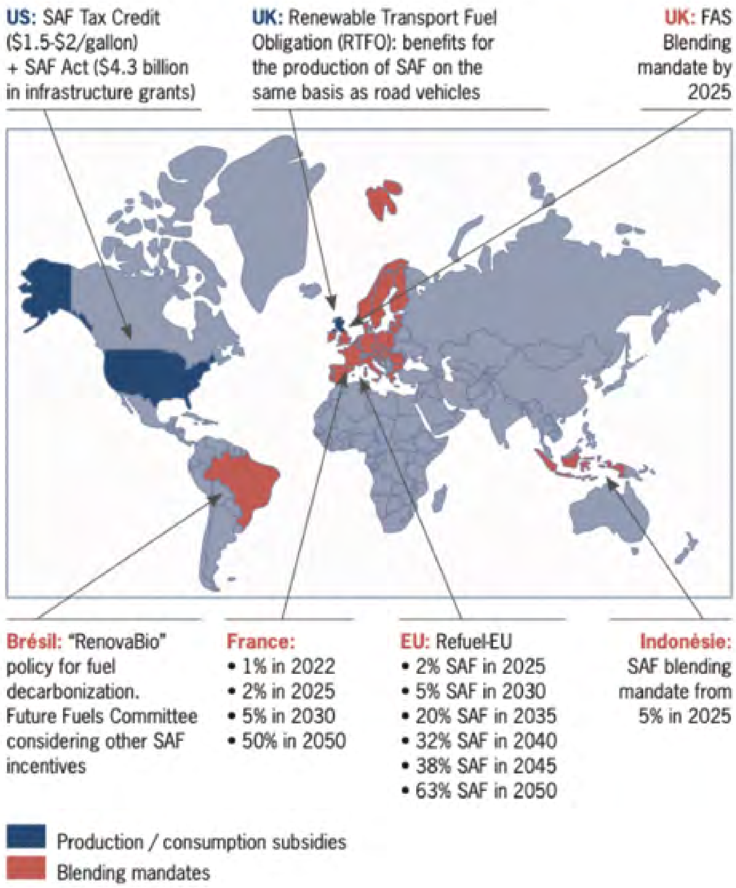
Level of coverage of EU-ETS and CORSIA mechanisms by region and type of journey



Source: Public data; Archery Strategy Consulting Analysis

ANNEX 7

Overview of incentives for SAF use around the world



Source: Public data; Archry Strategy Consulting analysis
To see more precisely : : https://lookerstudio.google.com/u/0/reporting/bc3ac20e-743e-46d9-a650-d8de24662b43/page/03OcC

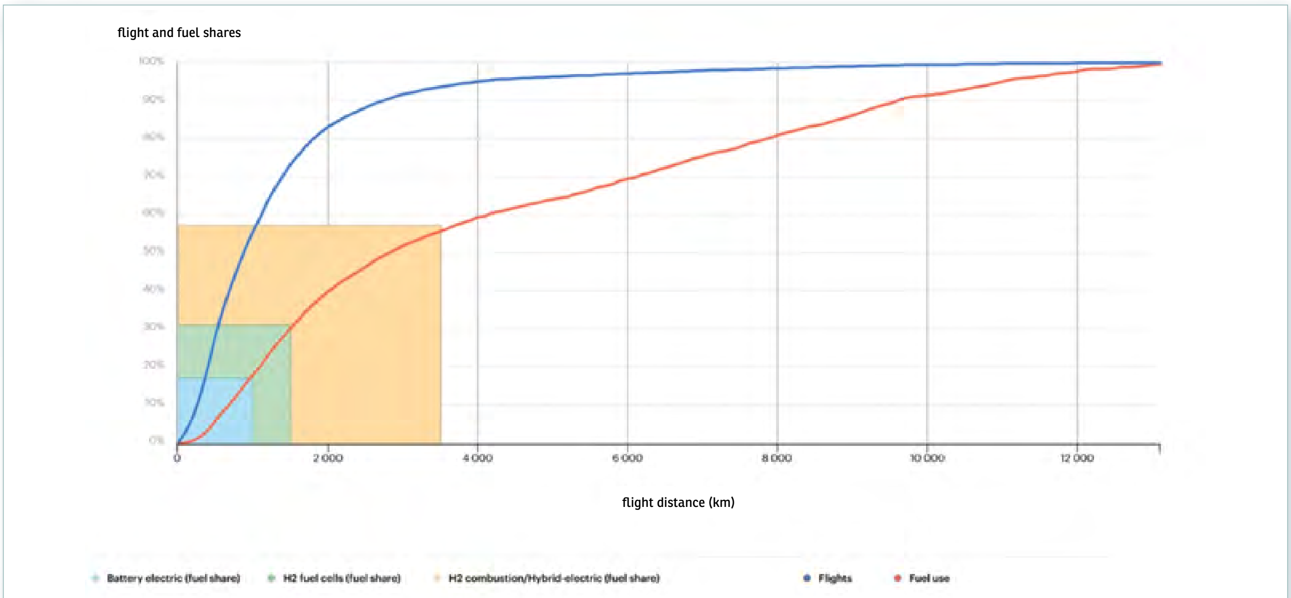
ANNEX 8

Summary of the policies (adopted and under development) to foster the use of SAF and Lower Carbon Aviation Fuels

ANNEX 9

To look forward on new technologies capacities:

The IAE is not categorical on the certainty of the path to take concerning future technologies, in particular hydrogen and electric battery aircraft.



Source: IEA

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- https://www.transportenvironment.org/wp-content/uploads/2021/03/Ares20211459392.pdf
- https://www.ft.com/content/628534ad-5dcc-4160-84f8-69e6d5df0098?accessToken=zwAF_wQA_Htgkc9ihTStXcxBYNOE-Gnm1d8AmA.MEUCIQDw-MxCpVvN25YjhUW2f8RNzvisXC_kTgC5st7-H09OiAIgdNiO_ZtkGIDAZAJW9m_Q_0Hh62Ze-dq_Vm6J5p8_Lzw&sharetype=gift&token=fa0d1263-b8ab-4f0c-b276-7d5267751d3e
- https://www.transportenvironment.org/discover/revealed-unpublished-eu-analysis-scathing-airline-co2-deal/