BRIEFING

Building the future of zero-emission and hybrid aircraft in Europe

Report published: 11 June 2026
Lead authors: Sofia Villani, sofia.villani@transportenvironment.org, Carlos López de la Osa García, carlos.lopez@transportenvironment.org
Contributors: Diane Vitry diane.vitry@transportenvironment.org, Vincent De Haes vincent.dehaes@transportenvironment.org

Summary

European companies are developing the next generation of disruptive aircraft. Zero-emission and hybrid-powered aircraft (ZEHA) can help bring aviation closer to decarbonised flying, while strengthening Europe's industrial competitiveness and technological leadership. By using renewable electricity and green hydrogen produced in Europe, these aircraft will reduce the sector's exposure to fossil fuel imports, and their development will help secure the future of aviation manufacturing in the continent.

ZEHA aircraft will not reach the market by themselves. Past research and development (R&D) support has failed to bring to market disruptive technologies at the speed required to meet decarbonisation targets. New, innovative companies face challenges to scale up and get to market in the EU, while China and the US increase competition.

Moreover, current aviation regulations were built around kerosene-powered aircraft. Weight-based charges penalise cleaner aircraft with heavier propulsion systems. Slot rules protect incumbent operations. Clean fuel mandates do not yet fully recognise renewable electricity. The result is a framework that still reflects the needs of conventional aircraft, even as new propulsion technologies move closer to market.

Getting ZEHA to market requires action across three connected areas: research and development (R&D), industrialisation and market creation. The next Multiannual Financial Framework (MFF), the upcoming Aviation Strategy and several legislative reviews, including the Airport Fitness Check, the Alternative Fuels Infrastructure Regulation (AFIR) and the Air Services Regulation, will determine whether ZEHA can move from promising European projects to commercial aircraft operating on European routes.

On research and development, EU funding should focus on high-risk, high-reward propulsion technologies and new aircraft architectures rather than incremental improvements to conventional designs. R&D funding should reach new entrants developing disruptive technologies, alongside stronger partnerships with established manufacturers.

Europe needs to close the gap between research and commercial production. European aircraft developers need financial support to move through certification, industrialisation and first-of-a-kind production. This means using the next EU budget (the MFF) and instruments such as the European Competitiveness Fund to leverage private investment, while ensuring that EASA has the resources needed to certify new propulsion technologies safely and in time.

Aviation legislation must also help create the first market for these aircraft. Underpinning this is the polluter pays principle. Fossil jet fuel remains too cheap compared with its climate impact, weakening the business case for cleaner alternatives like ZEHA. A broader and more effective EU ETS, alongside jet fuel taxation, would help close the price gap between polluting aircraft and

cleaner technologies. Part of the revenues should be reinvested into aviation decarbonisation through instruments such as the Innovation Fund, so that the sector finances its own transition.

Furthermore, the EU should provide targeted support to reduce the cost gap for early ZEHA operations, while adapting airport and air navigation charges, slot rules and airport infrastructure planning, and leveraging Public Service Obligations routes, to create a favourable environment for cleaner aircraft.

In the different aviation policies listed above, the focus should be on environmental modulation rather than rigid aircraft categories. Where charges, slots, tenders or support mechanisms are adjusted, they should reflect certified environmental benefits, lower CO_2, air pollutants and noise impacts. This keeps the framework technology-neutral and ensures support goes to the technologies that deliver the greatest environmental gains.

Europe has the developers, the industrial base and, with the right legislative choices in the coming years, an opportunity to lead the next generation of commercial aviation.

Key recommendations

1. The right support for the right technologies and the right organisations. Ensure the next MFF delivers for ZEHA by ringfencing €1 billion of the Clean Aviation successor programme to develop electric and hydrogen technologies. Facilitate support for new entrants at both R&D level, and through industrialisation.

2. Leverage existing aviation legislation to create the right conditions for ZEHA. Strengthen the polluter pays principle to send a price signal and reinvest part of the revenues. Introduce financial mechanisms in ReFuelEU or EU ETS to help cover the early cost gaps of ZEHA. Use PSO routes as an early market for cleaner aircraft. Revise airport and air navigation charges to ensure infrastructure will be ready for the deployment of ZEHA, and that these new aircraft will not pay higher charges than polluting, traditional planes.

3. Tap into the potential of private jets as a premium market for ZEHA deployment. Introduce a progressive ban on private flights below 1000 km by 2030, unless operated by ZEHA. Create a taxation framework for private jets commensurate with their environmental impact, including the application of EU ETS and ReFuelEU, to ensure wealthy flyers contribute their fair share to greening the sector.

Definitions

Within this policy paper, ZEHA technologies are categorized according to the following criteria:

- **Electric aircraft** refers to aircraft propelled by electric motors, totally or partly powered by ground-charged batteries.
- **Hybrid aircraft** are propelled by electric motors, powered by a combination of ground-charged batteries and a gas turbine using fossil kerosene or SAF - akin to a car "plug-in hybrid" configuration. The gas turbine power may be used together with the battery power, or as a range extender once the battery power is exhausted.
- **Hydrogen aircraft** refers to aircraft using hydrogen as their main energy carrier, either through direct combustion - similar to existing jet turbine engines - or through a fuel cell to power an electric motor.
- **Zero-emission aircraft** refers to aircraft that do not produce any CO_2 emissions in flight. This term encompasses hydrogen aircraft and fully electric aircraft, solely powered by ground-charged batteries.

Other configurations, where electric power assists a jet-fuel powered turbine, such as micro hybrid propulsion systems, have not been considered within the "hybrid aircraft" definition in this briefing. Micro hybrids do not have plug-in, ground charged batteries, and aircraft propulsion comes from the mechanical power of the jet engine, rather than from an electric motor. While micro hybrids will help increase the efficiency over previous generations of jet engines, aircraft with these technologies fall short of the relative emission reductions of the hybrid aircraft configurations defined above, which are expected to cut carbon emissions by 50% or more.

The next MFF will be key to develop zero-emission and hybrid aircraft technologies and bring them to market

The design of the EU's next Multiannual Financial Framework (MFF) comes just as many European companies are breaking ground on ZEHA. A careful design of the MFF, with targeted investments and an efficient use of public funds, can create the right conditions for these European pioneers to thrive. This would ensure that the future of flying is made in Europe, contributing to the competitiveness and decarbonisation of the sector. Failure to act ambitiously would risk Europe losing yet another tech battle to China or the US.

1.1 The Clean Aviation programme successor should target high risk, high reward technologies

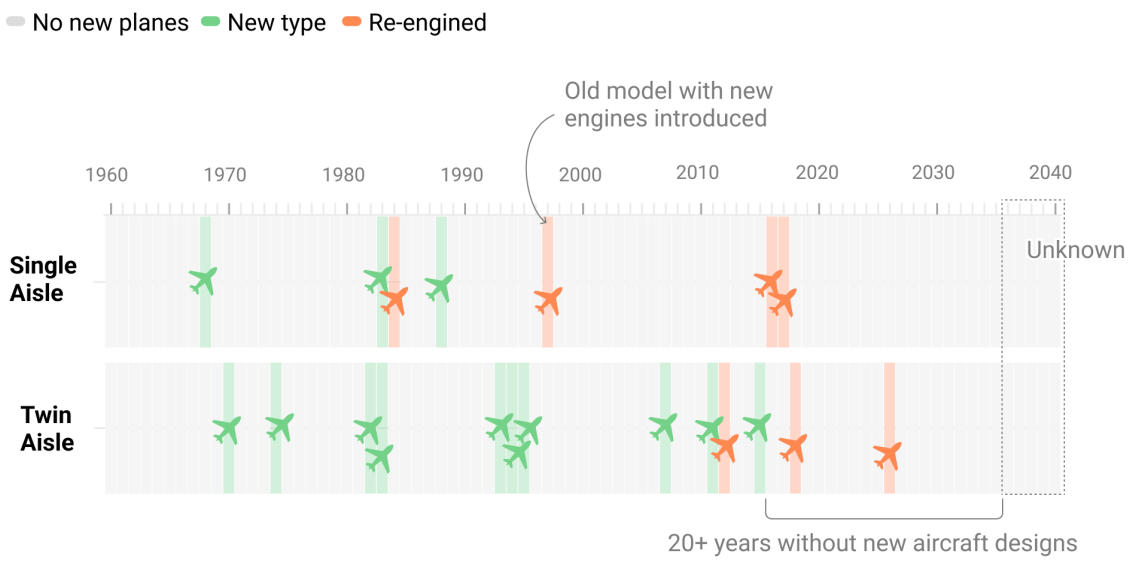
Repeated delays in aircraft technology innovation are hindering aviation's green transition. Innovation in the aviation sector has steeply declined over the past decades, with no new aircraft models expected in the next ten years either. Although Airbus and Boeing – the world's two biggest aircraft manufacturers – have unveiled new disruptive designs, including the world's first large hydrogen aircraft, these have been delayed or paused. The only significant efficiency improvements which have seen the light of day have come from fitting new engines onto existing airframes. In the meantime, structural and aerodynamic efficiency improvements have been modest at best.

However, T&E analysis suggests that European aviation could be up to 13% more efficient by 2050 in an ambitious innovation scenario, consisting of regional electric and hydrogen aircraft introduced by 2030, and a new short and medium range (SMR) aircraft by 2035. This efficiency boost would reduce emissions and Europe's dependency on imported fossil fuels.

To aim towards the ambitious, innovative scenario, a shift in R&D support for aircraft innovation will be the foundational first step.

Fewer new aircraft models are entering the market

An unprecedented 20+ year period without new aircraft designs from Airbus and Boeing is expected



Source: Airbus, Boeing, industry information

T&E

The Clean Aviation Joint Undertaking is currently the main EU instrument funding aviation research and development today. It operates as a public-private partnership under Horizon Europe, with a total envelope of €4.1 billion for 2021 to 2027, of which €1.7 billion come from Horizon Europe, and €2.4 billion are contributions from participating private companies.

The Commission's proposal for the next MFF introduces the next Research and Innovation Framework Programme (FP10) with a funding of €175 billion, doubled from the current Horizon Europe envelope. Among eleven candidate priorities, it lists a Smart and Clean Aviation Moonshot, which would be funded jointly through FP10 and the new European Competitiveness Fund (ECF), and steered by a new Joint Undertaking (JU). This presents a significant opportunity for zero-emission and hybrid aircraft. Yet, it will only be useful if the funding is targeted and the work programme is designed to reflect the actual technology landscape.

First, the future Clean Aviation Moonshot should include a ring-fenced amount of at least €1 billion for zero-emission and hybrid aircraft technologies within the 2028 to 2034 envelope, covering battery-electric, hybrid-electric and hydrogen propulsion pathways in proportion to their deployment readiness. The aim should be to push aviation away from the logic of incremental improvements that has dominated the sector in the last decades, and into technologies that can make a real dent on emissions reduction.

Beyond funding the right types of technology, supporting the right beneficiaries will be just as important. The EU should ring fence part of the funds of the future programme for new entrants. This will increase the likelihood of the new technologies flying in the shortest possible time, as the business case of those new entrants rests on getting innovative aircraft designs to market.

Collaboration between those new entrants and incumbents, for example by co-leading Moonshot projects, will also be mutually beneficial. New players could learn from the industrial expertise of large, leading European companies, while incumbents would work on developing breakthrough technologies, potentially outside of their usual scope of operations.

1.2 The ECF will be key to get breakthrough technologies from lab to market

Research funding alone does not bring aircraft to market. The gap between a demonstrator and a certified, commercially produced aircraft, often referred to as "the valley of death", is where European clean-aviation developers are most exposed. This is the stage when European scale-ups today turn to US or Gulf investors because EU instruments cannot follow them.

Within the upcoming MFF, the European Competitiveness Fund (ECF) is poised to be the dedicated programme to support companies' scale-up. It should deploy financial instruments that tech start-ups and scale-ups, including manufacturers of ZEHA and suppliers of key components, will need to thrive in Europe. To ensure the ECF answers the needs of the ZEHA sector, its technologies should be included in the list of strategic technologies of the Net-Zero Industry Act (NZIA), and also made eligible under the ECF.

The Innovation Fund is the most direct existing tool for first-of-a-kind production of ZEHA. Funded by EU ETS revenues, it supports the development of decarbonisation technologies. Under the next MFF, it should work in synergy with the ECF, potentially under the governance of the Clean Transition and Industrial Decarbonisation window.

The Innovation Fund distributes revenues through grants or auctions. ZEHA start-up Aura Aero has already benefitted from an Innovation Fund grant of €95 million - which has helped them strengthen their industrial capabilities. Other ZEHA start-ups should be prioritised in the Fund's grant making process. On top of providing upfront funding, the Innovation Fund may introduce competitive bidding for ZEHA manufacturers. The programme would award fixed grants for every clean or hybrid unit actually produced and delivered. This performance-based approach ensures financial support scales up the technologies that prove most commercially successful.

The ECF should include the critical components that electric and hydrogen propulsion systems will require, including aviation-grade batteries, fuel cells, electric motors, power electronics, hydrogen storage systems, semiconductors and other safety-critical components. This support should be aligned with wider EU raw-material and semiconductor security policies, ensuring that the needs of clean-aircraft supply chains are reflected in the implementation of the Critical Raw Materials Act and related tools, including strategic projects, demand aggregation and offtake mechanisms, as well as in the upcoming review of the Chips Act. Among these components, the production of aviation-grade batteries stands out as a key strategic opportunity for Europe. While batteries for electric vehicles have become heavily commoditised and cost-driven, aircraft

batteries remain a highly specialised, R&D-intensive, high added value niche market. The EU, with its leadership in aviation safety standards, including the reference safety agency in the world, is uniquely positioned to lead this market over China and other regions. With the right R&D and industrialisation support under ECF, complemented by EIB instruments, aviation-grade batteries will also be made in Europe.

Beyond grants under the Innovation Fund and ECF, the EU has a range of instruments, such as equity, guarantees and loans, crucial to support the industrial scale up of new, innovative companies. European policymakers should create the enabling conditions so that ZEHA companies can access those instruments.

TechEU is a new programme from the European Investment Bank (EIB), aimed to fast track finance for technological innovation across the entire development pathway, from early TRL to market. The programme should establish a dedicated Aviation TechEU sub-programme on the model of Space TechEU. An indicative envelope of €500 million in EIB lending and guarantees, mobilising €1 to 1.5 billion with commercial co-financiers, would unlock the venture debt and project finance that grants alone cannot provide across the full range of ZEHA developers.

The Scaleup Europe Fund is a new EU vehicle within the European Innovation Council. It aims at closing Europe's late-stage financing gap, designed to lead European-anchored equity funding rounds above €50 million in strategic deep technologies. Right now, ZEHA technologies are absent from the programme's strategic list. Listing those technologies would ensure that European ZEHA developers can raise growth rounds in the EU, and avoid taking intellectual property, supply chains and manufacturing capacity to third countries.

Finally, besides funding ZEHA developers and associated supply chains, the EU must ensure that essential actors receive the right amount of resources to support ZEHA development. Among those actors, the European Aviation Safety Agency (EASA) emerges as a pivotal one. In the coming years, EASA will need to ensure that new aircraft projects from new OEMs, based on technologies with little or no in-service experience, comply with the highest safety standards. The EU Commission and Member States must ensure that EASA has the right staff, expertise and financial resources to perform this critical task. Some successful examples show that joint collaboration between EASA and developers of ZEHA technologies will be key to make sure these new aircraft reach the market at the right time while complying with the highest, world-leading safety standards.

Test arenas: proving new aircraft technologies in real life

The development of ZEHA represents one of the biggest leaps in aircraft technology since the dawn of the jet era. In a sector used to operating in predictable conditions with well known technologies, some actors may perceive this leap like a jump in the void.

To prove these new technologies, Avinor, the Norwegian airport operator, and CAA Norway, the Norwegian Civil Aviation Authority, have put in place a test arena. These organisations have created an ecosystem ready for electric and hydrogen aircraft, including airport infrastructure, charging points and Air Traffic Management (ATM), to operate electric and hydrogen aircraft. The test arena has successfully run 126 flights in six months, resulting in an insightful learning experience for all stakeholders from airports to safety authorities, ATM and operators.

Beyond the learnings, test arenas can also prove the feasibility of ZEHA technologies to prospect customers and investors, increasing their market and bankability.

For that reason, the EU and Member States should put in place a cross-border test arena in the EU, funded by FP10 and/or the ECF, to showcase the potential of made-in-Europe ZEHA technologies, and the readiness of the world's leading aviation ecosystem.

Recommendations

01	The Clean Aviation programme successor in the next MFF should move from incremental improvements to high risk, high reward technologies. It should ring fence €1 billion for electric, hybrid and hydrogen propulsion, and have dedicated support for new entrants.
02	The EU should create a coherent strategy to seamlessly support innovative new entrants from early TRL to market. The EU must ensure ZEHA companies have access to grants, equity, loans and guarantees from the ECF and EIB. On top of aircraft manufacturers, funding support should also benefit developers of critical components, especially batteries, and infrastructure. Finally, the EU and Member States should create test arenas to showcase the capabilities of ZEHA technologies, boosting interest from customers and investors.

Existing aviation legislation can boost the market uptake of zero-emission and hybrid aircraft

The EU and the industry should not assume that, once ZEHA are certified and produced, the market will just absorb them. The current aviation policy framework, with weight-based charges and fossil fuel subsidies, puts clean aircraft on the back foot vis-a-vis today's polluting planes. Not just that: the aviation sector lacks clear industrial targets, such as the CO_2 standards for road transport, to push the design and development of disruptive aircraft technologies.

However, with the right changes, aviation legislation can go from showstopper to catalyst of the uptake of ZEHA.

2.1 Pricing pollution is the cornerstone to make ZEHA competitive

Unlike other transport or energy sectors, aviation has enjoyed decades of tax exemptions. The sector is only partly covered by the EU ETS system, and is currently exempted from fuel tax and VAT. Furthermore, no centralized ticket tax or VAT across the EU exists today, and individual ticket taxes across Member States remain low and fragmented. This situation has led to an estimated tax gap of 47 billion euros in 2025.

The consequences of this tax gap are two-fold. First, fossil fuel-powered aircraft get a free pass to pollute, obtaining an unfair advantage over clean solutions like zero-emission (ZE) and hybrid planes. This creates a limited commercial case for the multi-billion-euro investments that these new, clean aircraft require. The market signal that should be driving those investments, namely the rising cost of polluting, has been deliberately suppressed.

On the other hand, some tax revenues, notably EU ETS, are reinvested in decarbonisation of aviation and the wider economy. Less taxation, including a reduced EU ETS scope, means fewer revenues, limiting the investment opportunities in decarbonisation.

Moreover, the lack of jet fuel taxation creates unfair anomalies, as electric planes currently pay more taxes for their renewable electricity than conventional planes pay for their fossil fuel.

Taxation measures to ensure the aviation sector pays for its pollution are therefore pivotal to help ZE and hybrid aircraft take off.

2.1.1 Proper pollution taxation, including extension of the EU ETS scope, would give zero-emission and hybrid planes a boost

Extending the EU carbon market to all departing flights and reinforcing its effectiveness is the essential first step the EU must take in the upcoming 2026 EU ETS directive revision. A meaningful and rising carbon price raises the operating cost of fossil-fuelled aircraft year after year, while simultaneously narrowing the price gap between today's polluting planes and more efficient planes, as well as zero-emission hydrogen and electric aircraft, that are technically feasible but commercially stranded.

T&E analysis, through the application of a total cost of ownership model, compared two scenarios: one in which the carbon market continues to apply only to intra-European flights and one in which it extends to full scope, covering all departing flights from 2027. The analysis shows that an additional carbon price of €121 per tonne of CO_2 would be sufficient to make cleaner aircraft cost-competitive with conventional alternatives at a system level. This figure sits within the range of carbon prices that current EU ETS projections already imply by the mid-2030s. The policy lever needed to tip the economics is not out of reach.

Extending the EU ETS scope would also increase yearly revenues from €3 billion in 2024 to €14 billion by 2030. A part of those additional revenues would flow back to ZEHA technologies through the Innovation Fund and other potential support mechanisms, largely financing the decarbonisation, strategic autonomy and future competitiveness of European aviation.

To ensure the sector pays a fair price for its environmental impacts, and to unlock substantial new revenues for Member States, decisive action must be taken.

First of all, the EU Commission should extend the scope of the EU ETS in its upcoming revision to cover all flights departing from Europe. This is essential to set a fairer price of flying that rewards cleaner ZE and hybrid aircraft. Additional funds would be generated, partly flowing back to the sector via the Innovation Fund and Member States, which makes a much stronger case for the EU ETS over offsetting measures like CORSIA, whose revenues do nothing for the sector.

To complement this measure, Member States should introduce taxation on aviation fossil fuels to end their long-standing exempt status and reverse the penalty placed on renewable electricity, and national ticket taxes at the Member State level to guarantee that aviation pays a fair price for its environmental impacts. Taxation schemes should be modulated based on emissions to ensure that those polluting the most, such as business travellers, contribute the most, while sustainability leaders are rewarded.

2.2 ReFuelEU and EU ETS can bridge early cost gaps between electric and hydrogen aircraft and polluting planes

Although the economic case for decarbonised solutions in the long run may be favourable in the long run over old technologies, the initial costs may sometimes be higher, due to lack of economies of scale, learning curves and other factors. This is the case for electric vehicles (EVs): their total cost of ownership (TCO) of EVs is falling below that of diesel and petrol cars, but was higher when the technology was first introduced. That is why policymakers across Europe and other regions used incentives to support EV adoption.

Zero-emission and hybrid aircraft are expected to follow the same logic. The TCO of electric and hydrogen planes is expected to go down in the coming years, but they may have a competitive disadvantage in their first years of operation. On top of increasing the cost of pollution, EU aviation legislation offers opportunities to introduce incentives that would align the environmental and commercial case of ZEHA.

2.2.1 ReFuelEU can help deploy electric and hydrogen aircraft through Clean Aviation Fuel Entitlements (CAFEs)

The ReFuelEU Regulation is essential for aviation decarbonization. It mandates the use of Sustainable Aviation Fuels (SAF), setting targets between now and 2050, to displace fossil fuel use. The operation of ZEHA will also lead to significant reductions in fossil jet fuel demand through the use of electricity and hydrogen, but the current regulatory framework does not fully cater for these types of planes.

At present, renewable hydrogen is included within ReFuelEU as a compliance mechanism for both the broader SAF targets and the synthetic sub-targets. However, renewable electricity is not yet part of the regulation, leaving a critical regulatory gap for electric aviation. T&E recommends the European Commission to include renewable electricity used to by electric and hybrid planes as an eligible energy carrier in its upcoming 2027 revision, to foster a truly technology-open framework.

With renewable electricity and hydrogen, ReFuelEU would offer fuel suppliers alternative pathways to comply with SAF targets. With the right measures, this could mobilise funds from big energy companies towards the development of ZEHA.

To achieve that goal, T&E recommends the establishment of Clean Aircraft Fuel Entitlements (CAFEs) to reward aircraft owners for the purchase and use of ZEHA. The system follows the logic of the German THG Quoten system, where owners of electric vehicles generate electricity credits that are then sold to fuel suppliers via a market intermediary. In the aviation context, ZEHA owners would receive CAFEs that would then be sold to fuel suppliers, who can use them to show compliance with ReFuelEU SAF targets through an energy-equivalent conversion.

The detailed process of the system would work as follows:

01 Aircraft manufacturers calculate the amount of electricity or hydrogen used by a given zero-emission or hybrid aircraft, based on aircraft specifications and typical missions, over a 10-year period. This period is defined to be shorter than the estimated lifespan of the aircraft, to provide a conservative estimate of kerosene displacement, and discount future savings. Actual kerosene displacement would very likely be higher, as the aircraft will operate over a longer time.

02 Authorities calculate the amount of fossil kerosene displaced by the use of hydrogen or electricity, using energy equivalence factors in the form of multipliers, as the ones used in the Renewable Energy Directive for the conversion of renewable electricity into an equivalent amount of fuel.

03 Authorities release one Clean Aviation Fuel Entitlement (CAFE) for each tonne of fossil kerosene displaced by hydrogen or electricity. The credits are released to legal entities - such as airlines, lessors or public buyers - placing binding hydrogen or electric aircraft purchase orders or pre-orders.

04 The first CAFE release would be upon the down payment for aircraft pre-order. The CAFE release should be proportional to the percentage of the total price paid upon pre-order, and it should be capped to 20% of the total CAFEs to avoid overusing future kerosene savings.

05 The second CAFE release would be upon aircraft delivery, with the release also capped at 20% of the total CAFEs.

06 The third CAFE release would be a gradual, yearly release over the first ten years of aircraft operation, of the remaining CAFEs generated by the aircraft.

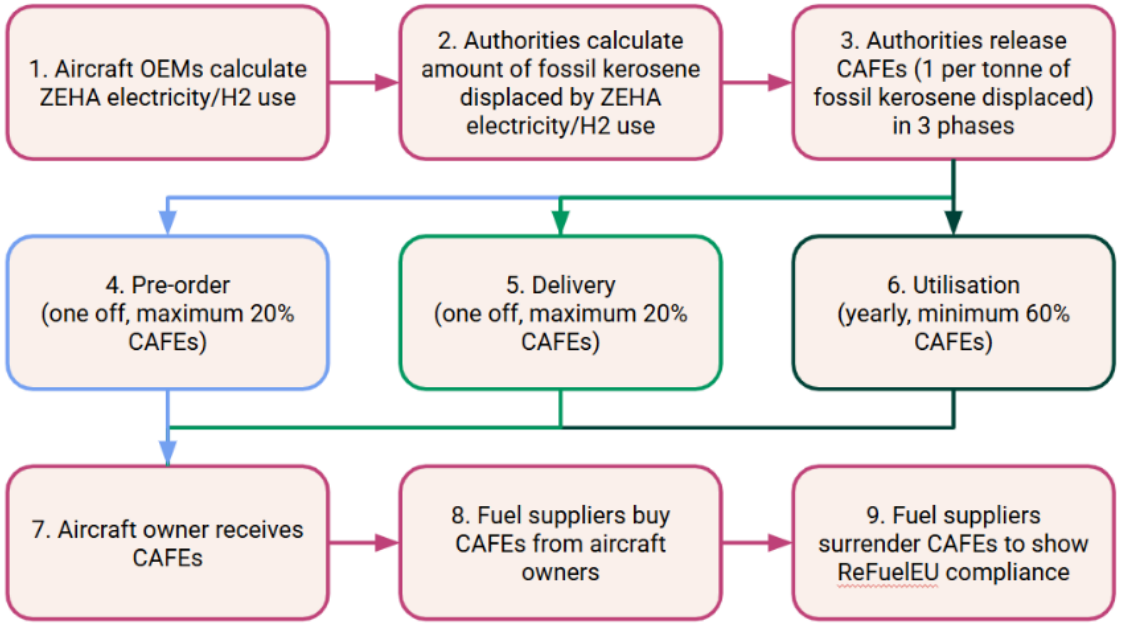
07 In all three phases, the aircraft owner receives the CAFEs.

08 CAFEs are sold by the aircraft owner to the highest-bidding fuel suppliers, with trading organized bilaterally or via specialized brokers and platforms, mirroring electricity-credit aggregators in road transport. To ensure maximum effectiveness, CAFEs must be freely tradeable.

09 Fuel suppliers can surrender CAFEs to cover part of their annual SAF regulatory obligations. To avoid cannibalising synthetic fuel production, CAFEs should be eligible to comply with overall SAF targets, but not eligible to comply with the synthetic fuel sub-target in ReFuelEU.

Clean Aviation Fuel Entitlements (CAFEs) would connect fuel supplier funds with ZEHA developers

The structured credit release, partly upon aircraft pre-order and partly upon delivery, will support aircraft orders, especially important for new market entrants



Source: T&E (2026)

The implementation of the CAFE structure ensures ReFuelEU becomes genuinely technology-open, generating benefits for different stakeholders across aviation's value chain. Airlines investing in ZE and hybrid aircraft obtain tradable credits that actively support their pre-order or purchase costs. Simultaneously, fuel suppliers are provided with a lower-cost

compliance option whenever CAFE prices fall below the marginal cost of physical SAF. Ultimately, this framework grants ZEHA manufacturers a powerful demand signal, converting future kerosene savings into a present-day, bankable compliance value that heavily supports both orders and long-term financing.

2.2.2 The EU ETS can issue free allowances to cover the cost gap of electricity and hydrogen against fossil fuels

Reinvesting revenues into the decarbonisation of aviation is a key pillar of the EU ETS. As part of the previous revision of the directive, co-legislators created a mechanism to bridge the cost differential between Sustainable Aviation Fuels (SAF) and fossil fuel. The mechanism, known as Fuels Eligible for ETS (FEETS), reserved 20 million EU ETS allowances from January 1 2024, and covers between 50% and 100% of the price gap between SAF and fossil kerosene.

With a strong participation in the first two years, this support scheme has proven effective to reduce the cost barriers of SAF use. As ZEHA are expected to enter the market in the coming years, extending the mechanism to cover electricity and hydrogen would be a logical development. This mechanism could complement the proposed Innovation Fund grants for aircraft purchases.

For electric planes, the energy-related costs would consist of the price of renewable electricity plus battery costs. The latter are important because, due to their heavy utilisation - deep charge/discharge cycles several times a day - aircraft batteries will need to be replaced often, even yearly, to maintain the high performance required for safe operations. The battery-related costs would cover the degradation during the support period, calculated as the number of cycles in the period over the estimated total number of cycles to replace the battery.

For hydrogen planes, the energy-related costs would relate to the hydrogen used.

In both cases, the support scheme should cover the gap between the hydrogen or the electricity-related costs - including battery costs - and the energy costs of an equivalent aircraft powered by fossil fuels. The equivalence should take into account the difference in aircraft propulsive efficiency between battery electric propulsion, hydrogen fuel cells, and jet turbines (either powered by jet fuel or hydrogen), in a similar way in which the Renewable Energy Directive introduces a multiplier of four in Article 27 for electric vehicles. In the case of aviation, we would propose a multiplier between three and four for electric aircraft, and between one point five and two for fuel cell-powered aircraft.

2.3 The Air Services Regulation can create an early market for ZEHA

The Air Services Regulation (ASR) is a central piece of aviation legislation, providing a unified legal framework for the operation of air services within the EU. This regulation has the potential to support the market entry of ZE and hybrid planes. Following a call for evidence and public consultation in 2025, the upcoming revision should ensure that the framework is fit for the deployment of ZEHA.

Two key changes could unlock this potential. First, modifying the conditions for Public Service Obligation (PSO) routes, many of which are well suited to ZEHA, to reward the use of aircraft with better environmental performance, and implementing the concept of Green PSO routes by reserving suitable routes for ZE and hybrid aircraft. And second, strengthening Article 20 and associated guidance to allow Member States to limit or refuse the exercise of air traffic rights on certain routes unless ZEHA aircraft are used, thereby creating a guaranteed market for these new technologies.

2.3.1 PSO tenders must include environmental performance in their evaluation criteria and provide longer contracts for ZEHA

PSO routes are scheduled air services established by Member States to guarantee essential connectivity to peripheral, isolated, or developing regions where market forces alone fail to provide adequate transportation.

As of March 2023, 77% of PSO routes in the EU were shorter than 500 km, and roughly a quarter have average occupations of 19 passengers or less. That makes them well suited to be operated by the first generation of ZE and hybrid planes.

Articles 16, 17 and 18 of the ASR provide the legal framework for PSO routes, while the EU Commission's Notice 2017/C 194/01 provides interpretative guidelines, including on PSO awarding criteria. Currently, that criteria is mostly based on the economic compensation for the PSO operator, with no explicit mention of environmental factors.

To foster the use of ZEHA in PSO routes, Article 16 of the ASR should be modified to mandate the inclusion of environmental performance as a key standard for PSO routes, alongside continuity, regularity, pricing and minimum capacity. The interpretative guidelines should also be modified to integrate environmental performance, measured by certified emissions of CO_2 and other pollutants such as NOx and PM, as a key quality indicator. The end goal should be that, when tendering for a PSO route, operators have a strong incentive to use cleaner aircraft, as this would grant them a higher evaluation than if they used a polluting plane. Member States can use examples like past tenders for public ferry services in Norway, where environmental criteria weighed between 20 and 30% of the total awarding criteria.

Furthermore, the maximum duration of PSO contracts in Article 16 should be extended from the current four or five years to six years for operators using the latest generation of ZE and hybrid aircraft. Longer contracts give operators the capacity to invest in new aircraft types.

2.3.2 Member States should create dedicated Green PSO routes for ZEHA

Beyond strengthening the weight of environmental performance in the ASR, Member States should go further and reserve some PSO routes for zero-emissions and hybrid aircraft. Member States should target short routes, particularly below 500 km, and "thin", with low passenger density. These routes perfectly match the range and capacity specifications of these new planes.

By introducing these "Green PSOs" with explicit environmental requirements into aviation tenders, governments can secure early market demand for ZE and hybrid planes, provide first-mover airlines with the financial certainty needed to overcome high initial capital costs, and successfully decarbonize regional air connectivity.

To successfully fund this, Member States can use EU ETS revenues, and also leverage public procurement and state aid. Under existing EU state aid rules, optional sustainability criteria are available, allowing governments to use the Most Economically Advantageous Tender (MEAT) and Green Public Procurement (GPP) methodologies. These principles go beyond the lowest price criterion, considering also environmental performance, and best value for money in terms of quality, social factors, life cycle costs and innovation. By actively integrating MEAT and GPP, Member States can embed strict environmental criteria directly into national and local procurement policies, ensuring that public resources are used sustainably for low-carbon technologies, for example to deploy Green PSO routes.

How European Member States are using public supported routes to deploy low-carbon vessels

The use of public service contracts has already proven to be a highly effective mechanism for deploying zero-emission maritime transport. Ferries providing essential, non-commercially viable connectivity to remote regions frequently operate under PSOs. Some European Member States have leveraged this mechanism, and also MEAT and GPP principles, to drive electrification in smaller, predictable ferry routes ideal for battery electric propulsion.

Norway offers a prime example. The Nordic country has modernized its ferry fleet by combining sustainable provisions in public support with strict environmental obligations, resulting in a growing share of electric and hybrid vessels.

Similarly, countries like Denmark and Spain already utilize MEAT and GPP principles to routinely include zero-emission criteria in their local ferry procurement policies.

These successful maritime practices show how PSO routes, MEAT and GPP principles can accelerate the deployment of zero-emission and hybrid transport technologies. Applying the same approach to aviation, once ZEHA get to market, is the logical next step.

2.3.3 The ASR can prioritise access to shorter routes for ZEHA

Article 20 of the ASR allows Member States to limit or refuse the exercise of air traffic rights on certain routes when serious environmental problems exist, in particular when other modes of transport provide appropriate levels of service.

This article has been the basis for the restriction of air routes in France with train connections under two and a half hours. This measure has reduced overall transport emissions while maintaining connectivity.

On top of the restriction of flights where rail connections exist, Article 20 could be used by Member States to limit the access of jet-fuel powered aircraft to air routes suited for ZE and hybrid aircraft. This measure would create a strong demand signal to accelerate the adoption of new aircraft technologies.

In practice, this measure can take the form of a progressive cap of CO_2 intensity per passenger kilometre. The cap should be modulated based on distance, with smaller caps in shorter routes, where pure zero-emission aircraft can start operating. Longer routes should have progressively higher caps, as aircraft architectures move from pure ZE, to hybrid, to pure jet-fuel powered aircraft. The cap should also be revised with time, to take into account technology progress and to adjust based on the delivery rates of ZE and hybrid aircraft.

The current absence of meaningful aircraft CO_2 standards hampers innovation in aircraft technology

ICAO introduced international aircraft CO_2 standards back in 2016, applying to both new designs and in-production aircraft. However, these standards have an extremely low level of ambition - as an example, most aircraft produced today already comply with the in-production standards that will be applied from 2035 onwards. Unlike EU car CO_2 standards, ICAO standards provide aircraft manufacturers zero incentives to innovate.

In the absence of strong standards to drive aircraft innovation, the introduction of a progressive cap to CO_2 intensity under Article 20 of the ASR could be a de facto CO_2 standard, at least for shorter routes. The distance-based modulation of the cap takes into account the range limitation of ZEHA technologies in air transport, while ensuring a clear demand signal.

2.4 AFIR holds the key to deploy electric and hydrogen infrastructure

The Alternative Fuels Infrastructure Regulation (AFIR), Regulation (EU) 2023/1804, has applied since April 2024. AFIR sets EU wide binding requirements for the rollout of alternative fuels infrastructures across different transport modes. For aviation, it already covers electricity supply to stationary aircraft at core and comprehensive Trans-European Transport Network airports. **A review is due by the end of 2026, which serves as a good moment to strengthen the regulation to make it more suited for ZEHA.**

AFIR gives the EU a starting point for airport electrification by requiring electricity supply to stationary aircraft at TEN-T airports. However, this narrow focus falls short of the needs of electric and hydrogen aircraft. The next AFIR revision should provide a framework for airport readiness for electric, hybrid-electric or hydrogen aircraft operations.

Article 12 requires electricity supply at remote stands by the end of 2029 and fossil-free electricity from 2030. **That provision was designed for ground power, not for aircraft charging.** The distinction matters. Supplying electricity to a parked conventional aircraft and charging a battery-electric aircraft are different technical requirements, with different power levels, different grid implications and different infrastructure timelines. The Combined Charging System 2 (CCS2) connector is currently available and in use, but electric aircraft will require the higher power levels of the Megawatt Charging System (MCS), already deployed for heavy-duty trucks. **AFIR does not yet address MCS for aviation.**

The 2026 review should assess power levels, charging interfaces and safety requirements for aviation, with explicit consideration of MCS alongside CCS2, with the option to define technical specifications through a delegated act as technologies and standards mature. If Member States deploy incompatible charging systems in the absence of a common standard, early operators will face additional barriers at every airport they serve.

Furthermore, early electric aircraft are likely to enter service first on short regional routes, at regional airports and secondary hubs. **Many of these airports sit outside the TEN-T core and comprehensive network and are therefore outside the current scope of AFIR.** The 2026 review **should extend its scope beyond the TEN-T network to cover the airports, infrastructure types and planning requirements that early zero-emission aircraft operations will actually need.**

AFIR should require Member States, through their National Policy Frameworks (NPF), to identify airports likely to host early electric aircraft operations. At those identified airports, a proportionate requirement should be introduced to provide electricity supply for a limited number of stands or dedicated operational areas, in line with projected operations.

AFIR should also require managing bodies of those airports identified in the NPF, together with the relevant electricity network operators, to prepare a forward-looking infrastructure readiness plan, **covering phased electricity demand, grid connection needs, reinforcement timelines and airside distribution upgrades.** The mismatch between aircraft deployment timelines and electricity network lead times is one of the most concrete barriers to early zero-emission aircraft operations. Anticipatory grid planning, ahead of firm demand justified by credible deployment scenarios, is the most direct way to address it.

Airlines operating or intending to operate electric or hybrid electric aircraft should have a right to access appropriate charging infrastructure at airports upon request. Airport managing bodies should be required to enable the provision of suitable charging infrastructure within a reasonable timeframe, including by facilitating access for third-party charging operators where they do not own or operate the infrastructure themselves.

Cost recovery must also be addressed. **Early zero-emission aircraft operators should not be asked to bear the full cost of airport electrification infrastructure alone.** AFIR should ensure that the costs of zero-emission aircraft-related infrastructure are recovered in a way that is reasonable and transparent, so that first movers are not structurally disadvantaged relative to later entrants. The 2026 review should also assess whether stronger links are needed between AFIR planning requirements and EU funding support, including through the Alternative Fuels Infrastructure Facility (AFIF), which should be extended beyond its current timeline to cover the 2026 to 2027 period.

Finally, in line with AFIR's technology-neutral approach, **the review should assess whether additional provisions are needed to anticipate airport readiness for hydrogen-powered aircraft**, covering spatial requirements, safety rules and logistical considerations. At present, hydrogen aircraft present a longer deployment horizon than electric aircraft, but the infrastructure lead times are also longer. In the first phase, hydrogen aircraft are likely to be refuelled by trucks, before dedicated airport infrastructure is developed.

Lessons from truck fast charging

When electric trucks moved from pilots to fleet deployment, the grid became a bottleneck. High-power charging required site upgrades, new grid connections and energy management systems that nobody had planned early enough. The same risk exists for electric aircraft and the window to act is narrower.

Charging an aircraft battery between flights is not the same as supplying ground power to a parked conventional aircraft. It requires higher MCS power levels already being deployed across European truck corridors, upgraded airside electricity distribution and sufficient grid capacity behind it. If airports wait for aircraft to arrive before planning the grid, infrastructure will be the constraint even when the technology is ready.

The truck sector settled on CCS2 for lower-power applications and MCS for high-power charging. Aviation needs the same clarity now, before airports deploy incompatible systems that create new barriers for early operators at every stop on their network.

2.5 Airport legislation should be adapted so that cleaner aircraft pay fair charges and get priority access

Airport rules will be an early test of whether Europe's aviation framework is ready for zero-emission and hybrid aircraft to operate at scale. Following the Commission's Fitness Check of EU airport legislation in 2025, any future review covering airport charges, slot allocation and groundhandling should assess whether these rules are fit for the deployment of cleaner aircraft. The EU should ensure that charges, slots, infrastructure access and energy planning help these aircraft enter the market, rather than locking in the advantages of today's fleet.

2.5.1 The Airport Charges Directive should mandate the environmental modulation of airport charges

The Airport Charges Directive governs how airport charges are consulted on, set and overseen at EU airports above five million yearly passengers. Many aircraft-related charges remain linked to traditional parameters such as aircraft weight, which is often used as a proxy for infrastructure use and cost recovery.

The consequences are particularly critical for ZEHA. Battery-electric and hydrogen aircraft can weigh more than conventional aircraft of the same size, because their propulsion systems and energy carriers are heavier. **Under a weight-based charging system, a cleaner aircraft may end up paying more than a more polluting one.** That is the wrong signal to send just as Europe is trying to bring these aircraft to market.

A solution to this anomaly would be to modulate airport charges based on environmental performance, so that cleaner aircraft, such as ZEHA, pay less charges than a jet-fuel aircraft of the same size. The EU already allows airports to modulate charges for environmental reasons under Directive 2009/12/EC. But because this remains optional, its use remains limited and fragmented. Most airports still do not apply meaningful environmental modulation, while those that do rely on different metrics and levels of ambition.

Importantly, the scope of the Airport Charges Directive is limited to airports above five million yearly passengers. This scope is too narrow for ZEHA deployment, as the first commercial ZEHA operations are likely to take place on short regional routes, often serving smaller regional airports and secondary hubs that fall outside the Directive's current threshold.

The EU should make environmental modulation of airport charges mandatory for all airports within the scope of the Directive, and extend the scope of this measure to smaller airports expected to host early ZEHA operations. This should be done by applying a common environmental correction to existing aircraft-related charges.

This environmental correction should be designed around certified landing and take-off emissions for CO_2, NOx, particulate matter and noise, giving rebates for aircraft that pollute less on those criteria. To be meaningful, the correction should create a clear charge differential, so that ZEHA pay a charge per seat equal to or less than the best conventional, jet fuel-powered aircraft in the same category. Anything below that level is unlikely to influence fleet investment or deployment decisions.

Fixing this requires a targeted revision of Directive 2009/12/EC. Specifically, Article 3 must switch from optional to mandatory environmental modulation, while Article 7 needs tightening to force airports to disclose their data baselines, methodologies and impact metrics. The detailed design should follow through implementing measures or Commission guidance, developed in consultation with airports, airlines, manufacturers and new entrants.

The system should be revenue-neutral. The purpose is to change who pays more within the existing airport charging systems, not to create new taxes. Existing airport schemes show that this can be done without redesigning airport charges from scratch.

Modulating charges is a reality at many European airports

Several European airports already apply environmental criteria within their airport charging systems. These schemes show that environmental modulation can be added to existing charges without replacing the underlying structure. They remain fragmented, however, and were not designed specifically around zero-emission and hybrid-electric aircraft.

Swedavia keeps the traditional weight-based airport charge in place and adds a separate CO_2-related element on top, based on certified landing and take-off cycle emissions data. For passenger aircraft, the assessment uses CO_2 per seat. For heavier aircraft and cargo operations, it shifts to CO_2 per tonne of maximum take-off weight. Swedavia also exempts fully electric aircraft powered by batteries or fuel cells from take-off charges entirely. It is a useful precedent. It is also a national, company-specific scheme, not a harmonised EU framework.

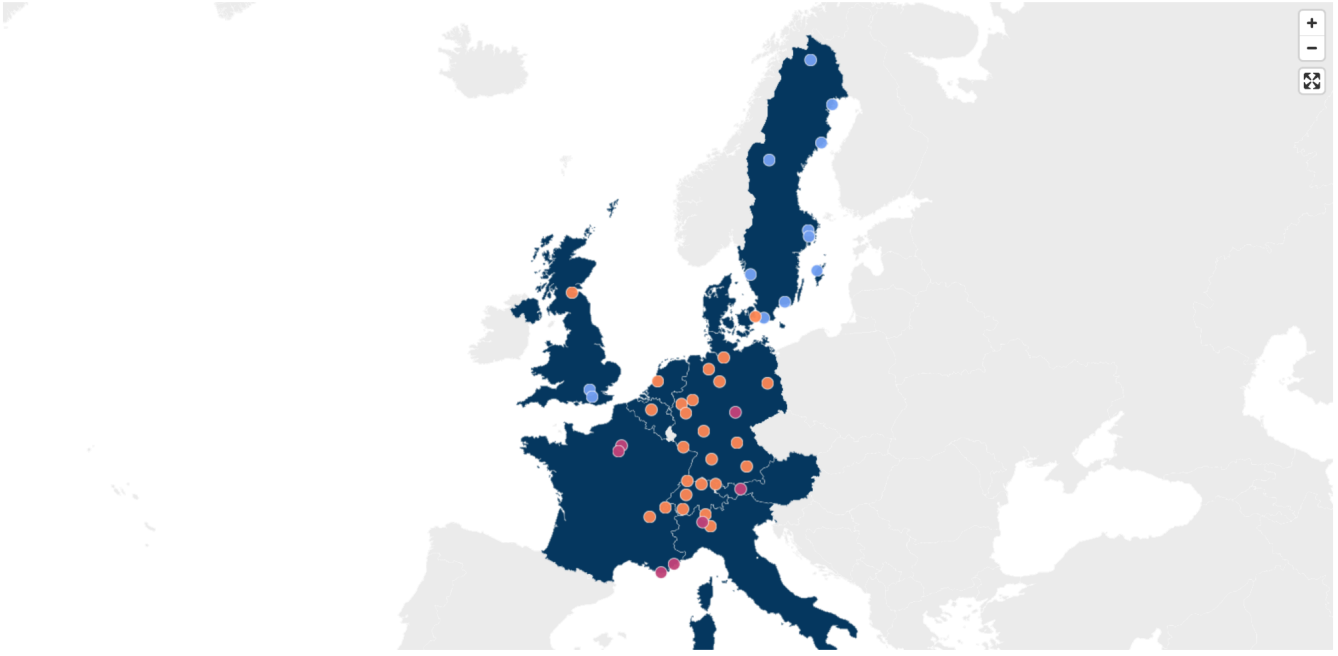
Lyon airport goes one step further in demonstrating what is technically possible. It applies a separate CO_2 bonus-penalty coefficient to its landing fee, calculated from the fuel burn of each aircraft during the landing and take-off cycle and identified by aircraft registration number. For passenger flights, the metric is kg CO_2 per offered seat, capped at 12% in either direction. Its landing fee already includes a noise modulation, and the two coexist within the same structure. Lyon also shows that airports can use existing certified engine data to assess performance at individual aircraft level. What it does not resolve is the scale of the signal. A 12% modulation on the landing fee alone is unlikely to influence fleet investment or deployment decisions for early zero-emission and hybrid-electric aircraft.

A harmonised EU framework should go further, requiring a charge differential strong enough to make zero-emission and hybrid-electric aircraft at least cost-competitive with the best conventional aircraft in the same category. Individual airport schemes, however well designed, cannot deliver that at scale.

Environmental modulation of airport charges across Europe

Airports in 10 European countries already apply modulation of airport charges based on different environmental criteria

- Countries with airports applying environmental modulation of charges
- Full environmental modulation
- Two-component modulation
- Single-component modulation



Source: Public information available online.
Components for environmental criteria: noise, CO2 and air pollution (NOx and particulate matter emissions). Full environmental modulation: based on all three components. Two-component modulation: any combination of two out of the three components.

2.5.2 Cleaner aircraft should get priority airport access under the Slots Regulation

The EU Slot Regulation governs how take-off and landing slots are allocated at Europe's most congested airports. A slot is a permission to use airport infrastructure to operate a flight at a specific time and is allocated by independent coordinators. The total number of slots available at any airport is capped through coordination parameters, limits set by national authorities that reflect how many flights an airport can handle, taking into account operational and environmental constraints such as noise restrictions and movement caps.

Airlines that have operated a slot historically can keep it the following season if they use it at least 80% of the time (known as 80/20 use-it-or-lose-it rule). Slots not retained return to a pool for reallocation, with half reserved for new entrants under Article 10(6).

The result is a framework that is formally technology-neutral, but not neutral in its effects. Historic rights and the 80/20 use-it-or-lose-it rule protect incumbent operations. At congested airports, available pool slots are scarce, leaving little room for new operators and new aircraft technologies to establish a presence. In practice, the current rules tend to entrench existing conventional commercial aircraft operations rather than support the shift to cleaner aviation.

The Regulation already contains some environmental provisions. Coordination parameters can account for environmental constraints, which means environmental considerations already shape the total capacity made available for slot allocation. But once that ceiling is set, the allocation process is largely blind to what aircraft will actually fly those slots. **The Regulation can limit how many flights take place, but it says nothing about how clean they should be.**

The EU should amend the Slot Regulation so that certified environmental performance becomes an explicit criterion when slots are allocated from the pool. Environmental performance, defined through certified CO_2 performance during the landing and take-off cycle against a comparable current-generation aircraft, should be the primary benchmark. Where an airport faces noise or NOx-related capacity constraints, certified performance on those pollutants should also count, but only where the aircraft materially reduces the specific impact that justifies the local restriction. The detailed methodology should be developed through secondary legislation or Commission guidance, in consultation with airports, airlines, coordinators, manufacturers and new aircraft developers.

Applying this criterion uniformly across all coordinated airports from day one would be a mistake. Early zero-emission and hybrid-electric aircraft deployment is more likely on short regional routes and at secondary hubs than at the most congested long-haul airports. The measure should follow a phased approach. By 2030, environmental performance should be introduced as a pool-slot allocation criterion at coordinated regional airports, secondary hubs and airports identified in national planning under the Alternative Fuels Infrastructure Regulation as likely to host early zero-emission and hybrid-electric operations. By 2035, the criterion should apply to all coordinated airports, with the methodology adapted to the type of operation concerned.

Applying environmental performance is a targeted change; not a proposal to abolish historic rights or reopen the entire slot system. The focus is on slots that return to the pool and need to be reallocated. When those slots are reallocated, coordinators should consider the certified CO_2 performance of the aircraft operation during the landing and take-off cycle, assessed against a comparable current-generation conventional aircraft on the same type of operation. To ensure the mechanism rewards a genuine step change rather than incremental improvements, eligibility should require at least 55% less CO_2 compared with a comparable current-generation aircraft, in line with the threshold used in EU climate innovation funding. Zero-emission and hybrid-electric aircraft should be eligible under the same performance-based framework, but the level of priority should reflect their certified environmental performance. In practice, the strongest priority should go to aircraft operations with the lowest certified impact.

A temporary green priority mechanism within the slot pool should also be considered during the early market-entry phase. It would not create new slots or remove historic rights: it would apply only where slots return to the pool and two or more requests compete for the same slot. There is already a useful precedent: Article 10(6) reserves 50% of pool slots for new entrants because the slot system can make market entry structurally difficult. **The same logic applies to zero-emission and qualifying low-emission aircraft facing the same structural barrier.** Any such mechanism should include a review clause by 2035 to assess whether the threshold should be tightened or the priority phased out as cleaner aircraft reach meaningful market penetration.

A future revision of the Slot Regulation should provide a clearer procedural framework for cases where slots must be reduced or withdrawn for environmental or public-interest reasons. The current gap creates legal exposure for Member States, airports, coordinators and airlines alike. **Legal certainty here is not a technical detail.** This could be achieved by amending the allocation framework under Article 8 and the pool logic under Article 10.

Schiphol airport in the Netherlands shows both the relevance and the limits of the current framework. Coordination parameters at Schiphol reflect movement caps and night restrictions, environmental limits that shape how many slots exist. They do not determine who gets them.

Green comes first: parallels from the electricity sector

Renewable electricity did not scale in a fossil-based power system through market neutrality alone. EU law gave it targeted access rights. The 2009 Renewable Energy Directive required Member States to provide either priority or guaranteed grid access for electricity from renewable sources. Today's Electricity Regulation still preserves targeted priority dispatch for some renewable generators.

Airport slots should follow the same logic. Scarce infrastructure rules are not neutral when incumbents already hold most of the capacity. A temporary green priority in the slot pool

would not create new slots or remove historic rights. It would apply only when slots return to the pool. Where several operators request the same slot, coordinators should be able to prioritise the aircraft operation with the strongest certified environmental performance.

The priority should follow the aircraft operation, not the airline. If the airline switches back to a conventional aircraft, the priority should not carry over. This would give ZEHA aircraft a market-entry foothold without creating a permanent privilege.

2.5.3 Enabling competition and fair pricing in electric charging and hydrogen refuelling through the Ground Handling Directive

Directive 96/67/EC regulates access to the ground handling market at EU airports. Ground handling covers the full range of services aircraft require while on the ground, including ramp handling, aircraft servicing and fuel and oil handling. The Directive was adopted to open this market to competition and to prevent access to airport installations from becoming a barrier to service provision. It does this partly through Articles 8 and 16, which allow Member States to designate certain shared infrastructure as centralised and require that access to airport installations be granted on relevant, objective, transparent and non-discriminatory terms.

That framework is directly relevant to ZEHA. Some ground handling services rely on infrastructure that cannot realistically be duplicated by every supplier or airline. And where duplication is not possible or justified because of complexity, cost or safety, access should be shared.

This framework now needs to be updated for ZEHA. Electric charging, hydrogen storage and refuelling facilities, adapted stands and airside electricity distribution are shared airport systems on which zero-emission aircraft operations will depend. Without access to these systems, aircraft cannot be charged, refuelled or turned around. **As a result, new aircraft operators and energy-service providers will face barriers to entry before the market has even started.**

The risk is that if one airport body or incumbent supplier controls access to charging or hydrogen refuelling, a new aircraft operator may be unable to launch a route even where the aircraft and infrastructure exist. An energy-service provider may be kept out of the airport market if access conditions are unclear or negotiated without transparency. For a market that still needs to attract aircraft orders, route commitments and infrastructure investment, access rules need to be clear from the start.

The Groundhandling Directive should be revised to explicitly cover access conditions for the infrastructure and services that ZEHA aircraft depend on. This includes electric aircraft charging, hydrogen storage and refuelling, airside electricity distribution, adapted stands and associated safety procedures. The aim is not to prescribe specific technical solutions before the market has developed. It is to ensure that where these systems are shared or difficult to duplicate, access is governed by clear rules.

A future revision should do three things. First, it should clarify that zero-emission aircraft energy infrastructure can be treated as centralised airport infrastructure where duplication would be inefficient, impractical or unsafe. Duplication here means each operator building its own parallel system. For assets such as hydrogen storage, high-power airside charging or electricity distribution networks, that is often physically impossible, prohibitively costly or inconsistent with airport safety rules. Once classified in this way, access should be granted on relevant, objective, transparent and non-discriminatory terms. **This would prevent charging or hydrogen refuelling systems from becoming a new bottleneck at airport level.**

Second, the Directive should require transparency on access conditions and fee-setting methodologies. Aircraft operators, ground handlers and energy-service providers should be able to understand who can use the infrastructure, under what conditions and how fees are calculated. A new entrant cannot build a route or a business case around zero-emission aircraft if access to charging or hydrogen refuelling is uncertain or priced through opaque arrangements.

Third, oversight should be strengthened. The current framework is stronger on access principles than on monitoring. For clean aviation energy infrastructure, that is a weakness. Operators need clarity before they buy aircraft, launch routes or invest in airport energy systems. **National authorities should be able to monitor whether shared infrastructure is being managed on non-discriminatory terms and act where restrictions risk undermining competition or ZEHA deployment.**

Such a revision would complement rather than duplicate the Alternative Fuels Infrastructure Regulation. AFIR should help identify and plan the infrastructure needed at airports.The Groundhandling Directive should govern how that infrastructure is accessed once it exists. **Without that access layer, public investment in airport readiness could still be undermined by practical barriers on the ground.**

Within the Groundhandling Directive, the regulatory question is therefore not only how to finance or deploy this infrastructure. **It is how to ensure that, once deployed, it can be accessed by aircraft operators, ground handlers and energy-service providers on fair, transparent and non-discriminatory terms.**

2.6 Air navigation charges should have an environmental modulation

Air navigation charges are calculated through the EUROCONTROL route-charges system. The charge combines three elements: the distance flown, the unit rate set for each charging zone, and an aircraft weight factor based on certified maximum take-off weight (MTOW). In practice, this means that a heavier aircraft pays more to use the same airspace, even if it emits less.

Battery-electric, hydrogen-electric and hybrid-electric aircraft may carry additional weight because of batteries, tanks, fuel cells or electric propulsion systems. **Under the current formula, that additional weight can translate into higher charges, regardless of the aircraft's emissions performance**, penalising the technologies the EU is trying to bring to market.

Article 32 of Commission Implementing Regulation (EU) 2019/317 already allows Member States to modulate air navigation charges on a non-discriminatory, transparent and revenue-neutral basis, including to reduce the environmental impact of flying.This possibility should now be strengthened in the context of the Commission's ongoing assessment of a possible uniform environmental modulation of en-route air navigation service charges in view of Reference Period 5 (RP5), ensuring that cleaner aircraft are not penalised by the structural bias of MTOW-based charging. **An environmental performance factor should therefore be applied on top of the existing air navigation charging formula.** The underlying charge would still be calculated using distance, unit rate and MTOW, but the final charge would be adjusted according to the certified CO_2 performance of the aircraft operation compared with a relevant conventional benchmark.

The principle should mirror the approach proposed for airport charges: technology-neutral, but performance-based - in this case, using CO_2 emissions - so that ZEHA pay a charge per seat equal to or less than the best conventional, jet fuel-powered aircraft in the same category.

For example, if a heavier ZEHA pays a higher per-seat charge under the standard MTOW-based formula than a conventional aircraft on the same route, the environmental factor should reduce the charge to the ZEHA to correct that outcome. To maintain revenue neutrality, the foregone revenues would be recovered through the corresponding surcharges on the worse-performing aircraft or through the normal unit-rate adjustment process in the next charging period.

The environmental factor should therefore be understood as a correction to an unintended design flaw in the charging formula.

The financial effect on early ZEHA may be modest, especially on short regional routes where distance-based charges are low. That does not make the reform irrelevant. **The point is to remove a structural signal that works against cleaner aircraft by design**. A charging system aligned with EU aviation decarbonisation should not make an aircraft pay more simply because its cleaner propulsion system changes its weight profile.

Recommendations

01	The scope of the EU ETS should be extended to apply to flights departing from the EU. Strengthening the EU ETS would increase the revenues to be reinvested in the Innovation Fund and other decarbonisation instruments, and send a price signal in favour of cleaner aircraft.
02	The EU should create support mechanisms to bridge the costs between ZEHA and conventional planes. Within ReFuelEU, Clean Aviation Fuel Entitlements would generate SAF compliance credits that operators can sell to fuel suppliers.Under EU ETS, the FEETS mechanism could be extended to issue free allowances that would cover electricity, battery and hydrogen costs.

03	The Air Services Regulation holds the potential to create early ZEHA markets. Environmental performance should be included in the set of criteria to award PSO routes. Member States should create Green PSO routes for ZEHA. Finally, Article 20 of the ASR can be strengthened to reserve shorter routes for ZEHA.
04	The Alternative Fuels Infrastructure Regulation (AFIR) must apply to airports beyond the TEN-T comprehensive network. The National Policy Frameworks under AFIR must identify airports for early ZEHA deployment, including regional airports outside of TEN-T, as well as key investments such as grid access. Those investments should be covered by the Alternative Fuel Infrastructure Funds, which should be extended to cover the 2026-2027 period.
05	Airport legislation needs to be amended to adapt to ZEHA. Airport charges should be modulated based on environmental performance to avoid penalising ZEHA. The slots regulation should prioritise the access of ZEHA to the slots pool. Besides that, the Ground Handling Directive should cover the access conditions for the infrastructure and services for ZEHA aircraft, including for suppliers of electricity and hydrogen.
06	Air navigation charges should be modulated or adjusted to avoid penalising ZEHA. Following the logic of airport charges, air navigation charges should move away from a pure weight-based calculation so that ZEHA pay per-seat charges equal to or less than conventional aircraft.

Private jets can go from super polluters to early adopters of zero-emission and hybrid aircraft

Private jets, used by a wealthy elite, have an outsized climate impact. However, their size and type of operations, with half of their flights within Europe being shorter than 500 km, can be perfectly covered by the upcoming first generation of zero-emission and hybrid aircraft. Banning the use of fossil fuel-powered aircraft for short private flights would help create a premium market for ZEHA, and significantly reduce the environmental impact of private flying. This measure should be complemented by taxing the remaining private jet operations according to their impact, and reinvest part of those revenues into new aircraft technologies.

Private jets represent one of the most CO_2-intensive means of transportation. Despite being highly polluting, private aviation remains virtually untaxed and unregulated. Today, a large part of private jets are excluded from the EU ETS system and ReFuelEU obligations.

Ensuring that private jet flights need to comply with EU ETS and ReFuelEU obligations is the essential first step to make super wealthy flyers responsible for their pollution. However, considering the low price sensitivity of private jet users, introducing a progressive taxation scheme that goes beyond current EU ETS obligations is a no-regret step. The EU should also apply a tax on fossil jet fuel in line with the proposal from the Energy Taxation Directive, set at 0.38€ per litre, and introduce a distance-based taxation on fossil-powered private jets of 0.60€ per kilometre, enforcing a minimum tax of 360€.

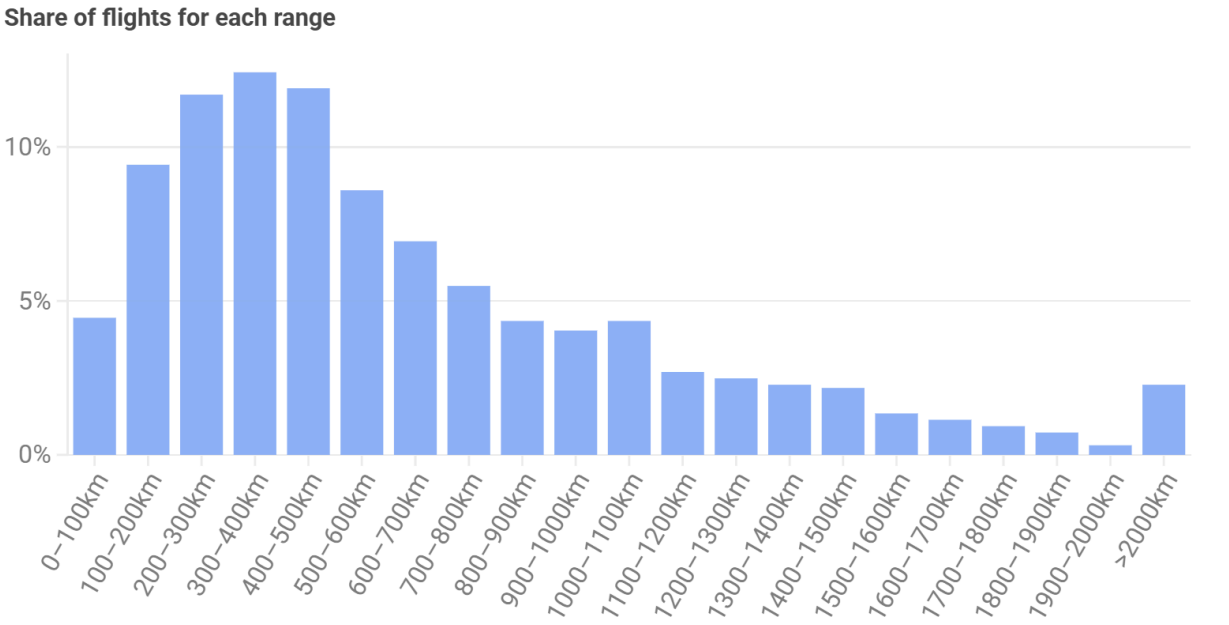
While such a scheme may have a limited impact on overall traffic volumes, it would be crucial to provide the critical funds necessary for aviation decarbonisation. The combination of all these taxes would generate revenues of more than €1.7 billion between 2027 and 2030 in the EU27 and UK combined. This would eliminate the unfair tax exemptions that the wealthiest flyers have benefitted from for decades, and would help create revenues that can be partly reinvested into greening the sector.

The structure of the sector reveals an opportunity to mandate technological shifts. Roughly half of all intra-European private jet flights in 2019 covered distances below 500 km, while close to

80% were shorter than 1000 km. These distances fall right within the operational range of first-generation ZEHA, making private aviation an attractive market for their rollout.

Nearly half of intra-EU private jet flights are shorter than 500 km

Four out of five private flights are shorter than 1000 km, falling squarely within the range of first generation zero-emission and hybrid aircraft



Source: T&E (2021), based on EBAA flight data for 2019

The EU should introduce a progressive ban on private flights below 1000 km, unless they are performed on ZE and hybrid aircraft. The EU could use article 20 of the Air Services Regulation, or a similar mechanism, to enforce this measure. This restriction should start as soon as ZEHA hit the market, expected by 2030. It should apply to high impact routes, creating a premium market for ZEHA. The restriction should be reviewed, and extended to longer distances, as technological evolution, particularly of batteries, increases the ranges of ZEHA.

Recommendations

01	Make sure private jets pay according to the pollution they create. Make EU ETS and ReFuelEU applicable to private flights, and introduce jet fuel tax and a dedicated ticket tax of 0.60€ per kilometre.
02	By 2030, ban private flights unless performed by a zero-emission or hybrid aircraft. ZEHA have the perfect range and size to cover most intra-European private flights.

Recommendations

01 The Clean Aviation programme successor in the next MFF should move from incremental improvements to high risk, high reward technologies. It should ring fence €1 billion for electric, hybrid and hydrogen propulsion, and have dedicated support for new entrants.

02 The EU should create a coherent strategy to seamlessly support innovative new entrants from early TRL to market. The EU must ensure ZEHA companies have access to grants, equity, loans and guarantees from the ECF and EIB. On top of aircraft manufacturers, funding support should also benefit developers of critical components, especially batteries, and infrastructure. Creating test arenas would showcase the capabilities of ZEHA technologies, boosting interest from customers and investors.

03 The scope of the EU ETS should be extended to apply to flights departing from the EU. Strengthening the EU ETS would increase the revenues to be reinvested in the Innovation Fund and other decarbonisation instruments, and send a price signal in favour of cleaner aircraft.

04 The EU should create support mechanisms to bridge the costs between ZEHA and conventional planes. Within ReFuelEU, Clean Aviation Fuel Entitlements would generate SAF compliance credits that operators can sell to fuel suppliers.Under EU ETS, the FEETS mechanism could be extended to issue free allowances that would cover electricity, battery and hydrogen costs.

05 The Air Services Regulation holds the potential to create early ZEHA markets. Environmental performance should be included in the set of criteria to award PSO routes. Member States should create Green PSO routes for ZEHA. Finally, Article 20 of the ASR can be strengthened to reserve shorter routes for ZEHA.

06 The Alternative Fuels Infrastructure Regulation (AFIR) must apply to airports beyond the TEN-T comprehensive network. The National Policy Frameworks under AFIR must identify airports for early ZEHA deployment, including regional airports outside of TEN-T, as well as key investments such as grid access. Those investments should be covered by the Alternative Fuel Infrastructure Funds, which should be extended to cover the 2026-2027 period.

07

Airport legislation needs to be amended to adapt to ZEHA. Airport charges should be modulated based on environmental performance to avoid penalising ZEHA. The slots regulation should prioritise the access of ZEHA to the slots pool. Besides that, the Ground Handling Directive should cover the access conditions for the infrastructure and services for ZEHA aircraft, including for suppliers of electricity and hydrogen.

08

Air navigation charges should be modulated or adjusted to avoid penalising ZEHA. Following the logic of airport charges, air navigation charges should move away from a pure weight-based calculation so that ZEHA pay per-seat charges equal to or less than conventional aircraft.

09

Turn private jets from super polluters to early ZEHA adopters. Ban private flights below 1000 km by 2030 unless performed by a zero-emission or hybrid aircraft, and increasing the range as ZEHA technologies evolve. Make EU ETS and ReFuelEU applicable to private flights, and introduce jet fuel tax and a dedicated ticket tax of 0.60€ per kilometre, to send a price signal in favour of clean technologies and generate decarbonisation revenues.

Further information

Sofia Villani
Junior Policy Officer
sofia.villani@transportenvironment.org

Carlos López de la Osa García
Aviation Technical Manager
carlos.lopez@transportenvironment.org

www.transportenvironment.org | BlueSky | LinkedIn