POLICY BRIEF

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Aviation EU Policy Brief
by Future Cleantech Architects

Navigating the way to a sustainable aviation future

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Executive Summary

Currently, aviation accounts for 2.5% of all global and 5% of the EU's total annual CO_2 emissions and is the fastest-growing emitter in the transport sector. Demand is projected to more than double by 2050 and emissions will only even begin to decouple from demand after 2030. While efforts are already being devoted, both globally and in the EU, to decarbonize, current implemented policies are expected to lead to a drop in global CO_2 emissions of only ~20%, while Europe is predicted to fare slightly better, with a ~38% drop in emissions by 2050. Aviation is therefore not yet on track for net zero.

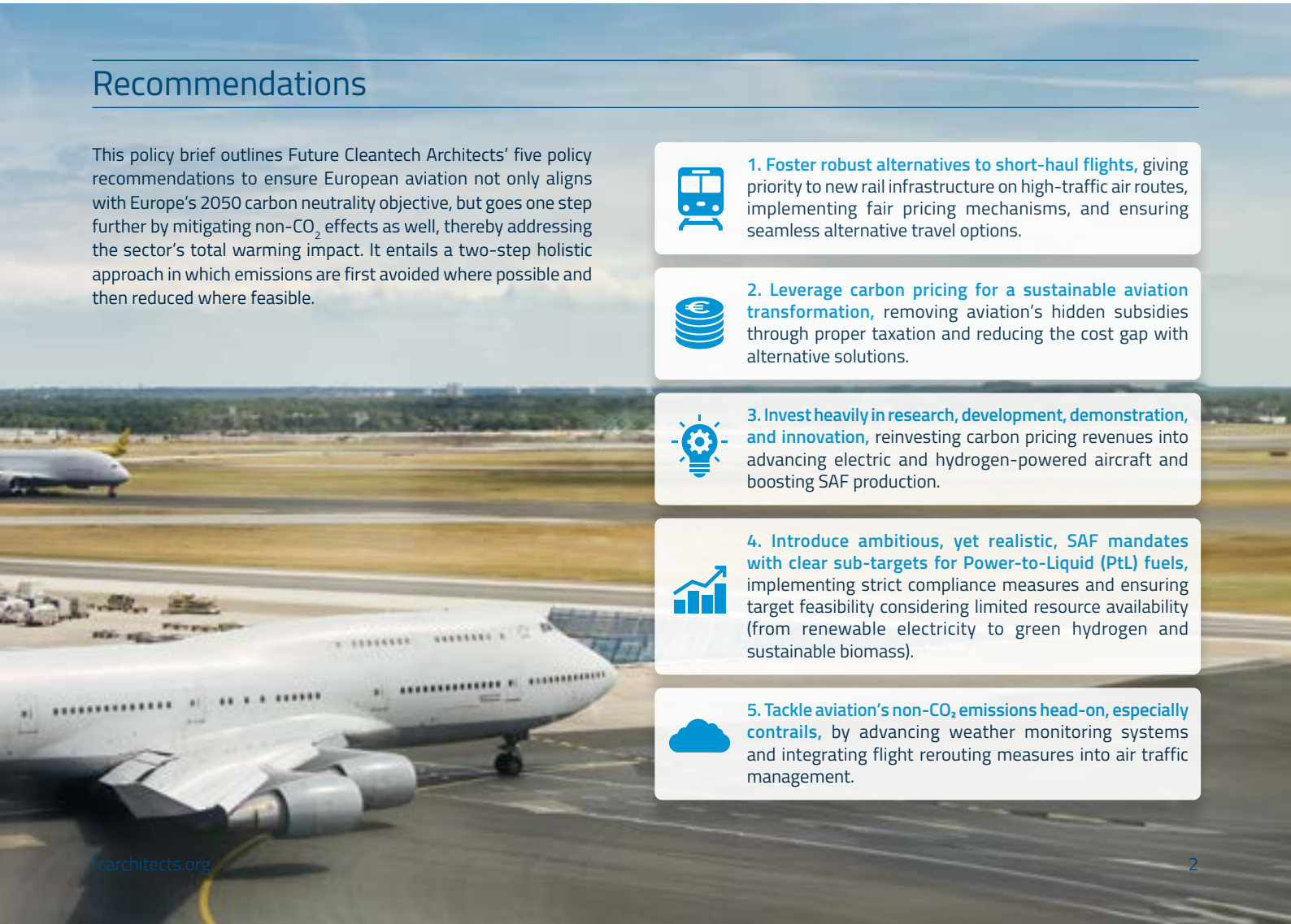
Current policies are not ambitious enough to eliminate the sector's emissions by 2050 and do not align with the EU's climate objectives. Additionally, the sector is quickly running out of time, as planes bought today will remain in operation for the next 20 years or more. Today's European regulatory frameworks are therefore crucial to shaping the sector's progress all the way to 2050.

Future Cleantech Architects (FCA) welcomes the EU's 2023 legislative milestones to accelerate the aviation sector's decarbonization. Under the new EU Emissions Trading System (ETS), the sector will no longer benefit from free allowances, as of 2026, and will be required to surrender allowances against its emissions. The ReFuelEU Aviation regulation sets mandatory targets for Sustainable Aviation Fuels (SAFs) and is complemented by the Alternative Fuels Infrastructure Regulation (AFIR), which recognizes the investment needed for electricity supply to stationary aircraft. The revised EU guidelines for funding the development of the trans-European transport network (TEN-T) also address ground operations and integrated infrastructure planning. Additionally, implementing the EU Sustainable and Smart Mobility strategy and milestones will help in reducing current fossil fuel dependence by doubling high-speed rail traffic across Europe by 2030.

However, this is only the start of the journey towards a sustainable aviation future. Achieving total emissions reductions requires global coordination, more ambitious policies that adhere to the 'polluter pays' principle, and addressing non-CO_2 emissions, which make up 60% of the sector's global warming impact but are still widely neglected.

Recommendations

This policy brief outlines Future Cleantech Architects' five policy recommendations to ensure European aviation not only aligns with Europe's 2050 carbon neutrality objective, but goes one step further by mitigating non-CO_2 effects as well, thereby addressing the sector's total warming impact. It entails a two-step holistic approach in which emissions are first avoided where possible and then reduced where feasible.



1. Foster robust alternatives to short-haul flights, giving priority to new rail infrastructure on high-traffic air routes, implementing fair pricing mechanisms, and ensuring seamless alternative travel options.

2. Leverage carbon pricing for a sustainable aviation transformation, removing aviation's hidden subsidies through proper taxation and reducing the cost gap with alternative solutions.

3. Invest heavily in research, development, demonstration, and innovation, reinvesting carbon pricing revenues into advancing electric and hydrogen-powered aircraft and boosting SAF production.

4. Introduce ambitious, yet realistic, SAF mandates with clear sub-targets for Power-to-Liquid (PtL) fuels, implementing strict compliance measures and ensuring target feasibility considering limited resource availability (from renewable electricity to green hydrogen and sustainable biomass).

5. Tackle aviation's non-CO_2 emissions head-on, especially contrails, by advancing weather monitoring systems and integrating flight rerouting measures into air traffic management.

Air travel is currently the fastest means of global transit. Aside from enabling touristic travel, aviation also facilitates trade and generates economic growth and employment opportunities. However, the sector's environmental impact is substantial, representing 2.5% of global CO_2 emissions, as can be seen in Fig. 1. In the EU, transport is the second largest emitter (after electricity and heat) and is responsible for ~30% of CO_2 emissions. To make matters worse, transport is the only sector in the EU whose emissions continue to rise, with aviation as its fastest growing emitter. Aviation makes up 18% of those transport emissions, the second largest emitter after road transport. Emissions from aviation have been steadily rising in the EU, increasing by 30% between 2013-2019, and making up 5% of the EU's total emissions in 2019.

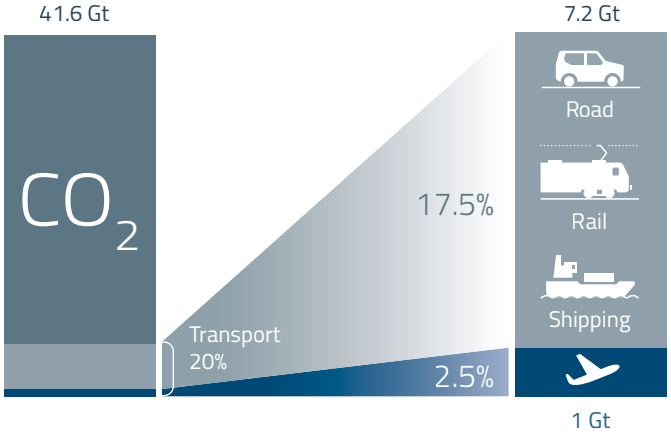


Figure 1. Global annual CO_2 emissions in 2019 and the share of annual emissions from the transport sector by mode of travel.

As the sector recovers from the impact of the COVID-19 pandemic, demand is expected to return to 2019 levels, both globally, as can be seen in Fig. 2, and within the EU, by 2025. By 2050, demand is predicted to more than double compared to 2019. Based on current implemented policies, growth and emissions will begin to decouple as of 2030, as seen in Fig. 2, with CO_2 emissions from air travel predicted to drop by a mere ~20% globally by 2050. In Europe, the outlook is slightly more encouraging, as the sector's emissions are set to reduce by ~38%, but current efforts are not ambitious enough to fully eliminate its CO_2 emissions by 2050. The situation is made worse by two factors:

- CO_2 is not the only or the largest contributor to aviation's global warming impact. 60% of the sector's warming impact on the planet comes from non-CO_2 emissions, particularly contrails, which thus far remain widely neglected in aviation sustainability strategies.
- Planes are built to last, with a lifetime of 20 years or more. Time is running out as the predominantly conventional planes leaving the production line today will continue to be in operation in 2050.

Several technological solutions have been put forth to help make air travel more sustainable by 2050, but each comes with caveats.

- Electric planes could be suitable for short-range flights with limited passenger capacity. To cater to longer distances and higher capacities past 2050, major breakthroughs in battery technologies are needed.

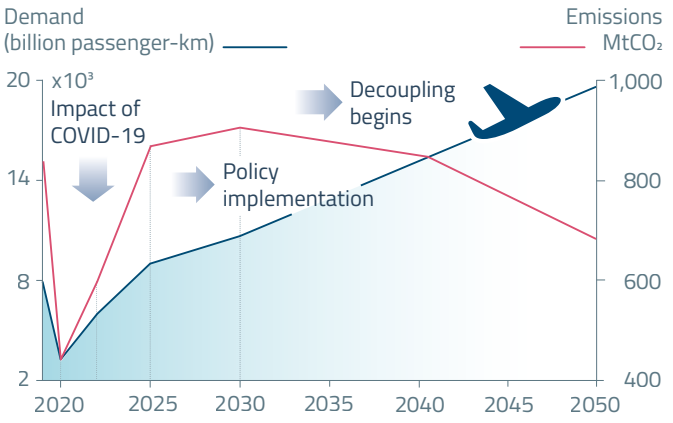


Figure 2. Projected global aviation demand (billion passenger-km) and emissions ($MtCO_2$) growth to 2050 based on current implemented ambitions.

- Hydrogen could service medium-range flights up to several thousand kilometers, but needs to overcome challenges in sourcing, transporting, and storing the hydrogen. In the long run, past 2050, flights with no range limitations could be serviced by hydrogen. However, that would require an aircraft redesign optimized for hydrogen (see Box 1).
- Sustainable Aviation Fuels (SAFs) are considered drop-in fuels[1] but face feedstock availability limitations and are more costly than conventional aviation fuel. To meet demand, a substantial ramp-up in production is needed. Additionally, SAFs can be produced from a wide variety of feedstocks; thus, ensuring a minimum sustainability standard based on lifecycle emissions is imperative.

Ensuring that these innovative solutions can succeed requires the support of comprehensive policy regulations that put minimizing aviation's environmental impact at the forefront.

Green hydrogen

Box 1

Currently, hydrogen is produced through carbon-intensive pathways and is still highly dependent on fossil fuels. Clean hydrogen will remain a scarce resource for the foreseeable future. Any future production of clean hydrogen should be prioritized to decarbonize current uses before considering its use in new sectors. Furthermore, it should only be deployed where it will deliver significant climate benefits and where other decarbonization options, such as direct electrification, are not technically feasible.

[1] Drop-in fuels are fuels that can be blended with conventional fossil-based aviation fuels and can be used directly in airplane engines in operation today without the need to modify the engine.

Five recommendations to policymakers

The sector faces the imperative to reduce its environmental impact, highlighted in the recent EU Communication on Europe's 2040 climate target and path to climate neutrality by 2050, a strategic and all-encompassing approach to bolster emissions reduction efforts is essential. Our policy recommendations aim to pave the way for a sustainable aviation sector by addressing key challenges and the sector's hidden emissions, as well as fostering innovation and promoting responsible practices.

1. Foster robust alternatives to short-haul flights

Short-haul flights (<1500km) make up around 75% of all passenger travel and are responsible for 25% of the sector's annual CO_2 emissions in Europe. Tackling emissions from these short-haul flights is a low-hanging fruit that can materialize with the right policy support and member state coordination.

- The installation of new rail infrastructure, especially high-speed rail (at least 160 km/h for all passenger lines on the main TEN-T rail stretches), on high-traffic air routes must be promoted to provide an alternative to flights up to 1500 km in range. Rail is one of the most energy-efficient and environmentally friendly modes of travel, especially in regions where 80% of trains are electric, as is the case in Europe.

- Increasing rail competitiveness must be accompanied by the 'polluter pays' principle. Pricing mechanisms for the various modes of transport must account for the mode's impact on the environment via schemes such as carbon pricing, congestion charges, etc.

- To maximize modal shift, costs for the passenger must be minimized. Thus, implementing the EU Sustainable and Smart Mobility Strategy will be crucial. The integration and connectivity of various modes of public transportation must be optimized to ensure a seamless, rapid journey for travelers with minimal changes. Digitalization in the form of real-time data and unified payment systems (e.g. moving towards contactless payment everywhere) across transport modes can also aid in increasing throughput.

Impact of the recommendation: shifting just 17% of flights <1500 km to rail (including night trains) will help eliminate 5% of the sector's emissions globally. With its high rail connectivity, 80% proportion of electric trains, and 69% traveler willingness to use night trains for flights <1500 km, Europe is a perfect example of the potential for even larger emissions savings by shifting short-haul air traffic to rail.

2. Leverage carbon pricing for sustainable aviation transformation

Since the late 1940s, when commercial aviation grew rapidly post World War II and became regulated through the signing of the Chicago Convention and the establishment of the International Civil Aviation Organization (ICAO), the sector has benefited from aviation fuel tax exemptions on commercial flights and a lower VAT on flight tickets, both globally and within the European Single Market.

- It is crucial to eliminate aviation's current tax benefits. While aviation fuel is still exempt from fuel taxation, other fuels, such as diesel, have been taxed within the EU for decades. Such a measure that could help incentivize the shift to more environmentally friendly alternatives and create a level playing field in terms of taxation across the transport sector. Currently, alternatives such as green hydrogen or power-to-liquid (PtL) fuels (produced from renewable energy) can be up to eight times more expensive. Having the sector adequately pay for its environmental impact will help narrow the cost gap between conventional aviation and more sustainable alternatives.

- Various taxation schemes must be simultaneously implemented to remove aviation's hidden subsidies. Ending free allowances for the sector in the EU Emissions Trading System (ETS) as of 2026 is a major first step (see Box 2 on CORSIA). However, increasing VAT rates on flights and taxing aviation fuel are still urgently needed, which could be further supplemented by a frequent flyer levy. If reinvested correctly, these mechanisms will help to significantly reduce the cost differential with alternatives such as SAFs.

- The next European Commission must prioritize revising the Energy Taxation Directive (ETD) to appropriately tax aviation fuel and ensure that EU ETS allowances support innovation in the aviation sector, overseen through rigorous monitoring by the European Commission and the European Parliament.

CORSIA

Box 2

International coordination for carbon pricing mechanisms, exemplified by the Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA), is crucial for ensuring a global level playing field. The EU must advocate for widespread participation in CORSIA to minimize market distortions and maintain its effectiveness by ensuring carbon offsets are not too cheap or oversupplied. However, it must be noted that carbon offsets on their own are not enough, they are merely one of many levers to encourage a shift to more sustainable practices.

Impact of the recommendation: A study by Transport & Environment (T&E) revealed that in 2022, European governments lost out on €34.2 billion of tax revenues from aviation due to inadequate taxation. These actions, if correctly reinvested in innovation, would help accelerate the deployment of sustainable solutions. By way of comparison, the European Innovation Fund's call for proposals amounted to €4 billion in 2023.

3. Invest heavily in research, development, demonstration, and innovation

Technologies that could help reduce aviation's emissions include all-electric and hydrogen planes, but both are still in their testing phase on smaller planes that are limited in both range and capacity. SAFs are considered drop-in fuels that can be used immediately with the highest emissions savings potential by 2050, but resource availability, production ramp-up, and guaranteed sustainability are a concern.

- Aviation start-ups and scale-ups across the world are on the rise, working on innovative solutions from electric and hydrogen aircraft to SAF production and route optimization. Incumbents are also looking at ways to make their aircraft cleaner, be it the producer or operator, while fuel producers are working on increasing the availability of SAFs from biofuels to PtL fuels.

- New tax revenue, as mentioned in recommendation 2 and Box 3, can be reinvested in sustainable initiatives, fostering research, development, and innovation to accelerate the sector's transition. This may include research into more fuel-efficient aircraft, the rapid deployment and uptake of SAFs, as well as the decarbonization of airport and aircraft ground operations in line with the AFIR deployment targets so that airports provide electricity to stationary aircraft at all gates by 2025, and at all remote stands by 2030. Ground operations alone constitute ~5% of the sector's total CO_2 emissions.

- This additional revenue can also be used to mitigate the risks of adopting low Technology Readiness Level (TRL) innovation by supporting demonstration projects that showcase the viability of new cleantech in real-world settings, for example, novel aircraft designs optimized for hydrogen use or novel battery technologies for longer distance all-electric flights. This approach can build confidence and reduce uncertainties related to security compliance and enforcement.

- Continuous ambitious support through the Innovation Fund, Horizon Europe, and the European Innovation Council is crucial to supporting breakthrough innovation in Europe from the laboratory to the market using an incubator approach.

Earmarking EU ETS revenues

Box 3

In January 2024, Future Cleantech Architects together with over 25 organizations, sent a joint letter to EU leaders as they traveled to Davos, highlighting the need to deliver the necessary investment for Europe's Net Zero Industrial and Cleantech aspirations. Member States should invest up to 25% of EU ETS revenues in scaling cleantech solutions and manufacturing, including for the aviation sector, and the budget of the Innovation Fund and European Innovation Council must be reinforced.

Impact of the recommendation: ambitiously deploying all-electric and hydrogen aircraft on feasible flights <4000 km by 2050 will help reduce the sector's total warming impact, which includes in-flight CO_2 and non-CO_2 emissions as well as upstream emissions, globally by 17%. As the share of emissions from flights within this range is similar between the EU and globally, this measure is expected to achieve similar levels of emissions savings within the EU.

4. Introduce ambitious, yet realistic, SAF mandates with clear sub-targets for PtL fuels

Until now, benefiting from free allowances under the EU ETS, there have been no concrete incentives for airlines to switch to more sustainable practices and significantly increase their uptake of alternative fuels. SAF mandates work as a market signal that there is demand for these alternative fuels, which in turn incentivizes the ramp-up in SAF production plants and thus the supply of SAFs on the market.

- In the newly adopted ReFuelEU Aviation regulation, SAF mandates contain stringent criteria for both production and usage markets. Effective penalties for non-compliance are also included to ensure adherence to the mandates. With the free ETS allowances in the EU ending by the start of 2026, these measures will reinforce each other and help accelerate the uptake of SAFs.

- In parallel, it is crucial to work on a minimum sustainability standard and common certification process to broaden the market for SAFs internationally. SAFs can be produced from many feedstocks and through various pathways, with a range of emissions savings and costs. To avoid market distortions, there needs to be a minimum agreed-upon standard of sustainability that is adhered to globally.

- Continuous R&D and investment (see recommendations 2 and 3) into new production pathways utilizing non-crop feedstocks is crucial to increase SAF availability. There are currently seven certified SAF pathways under ASTM D7566 (which includes the most common technological pathways HEFA, FT, and ATJ), but many other pathways are still under evaluation. Approval procedures for new pathways must be streamlined and accelerated, and permitting facilitated, to reduce barriers to entry for fuel producers.

- Demand for SAFs necessitates increased demand for scarce resources such as non-crop-based biomass, captured CO_2, renewable electricity, and green hydrogen (see Box 4). For SAF mandates to be effective and promote energy security, consideration must be given to their origin. This implies that the sources and SAF production pathways align with sustainability goals and do not compromise energy security.

- Continuous monitoring of progress is essential to ensure that targets are correct and feasible. This monitoring should allow EU policymakers to adjust policy frameworks and funding mechanisms based on interim results and scientific advancements. To kick-start PtL fuel production in the EU now, Future Cleantech Architects recommends that policymakers assess the feasibility of an earlier implementation of sub-targets for PtL fuels before 2030.

SAF production

Box 4

To meet ReFuelEU Aviation's 2030 targets, production of SAFs from biofuels must increase over tenfold in the EU (equivalent to a ~40% annual increase in capacity). Additionally, to produce PtL fuels, both CO_2, from sources such as Direct Air Capture (DAC) or sustainable bio-sources, and green hydrogen are needed, which require clean electricity for their production. For example, to meet the 2050 PtL sub-targets using green hydrogen and DAC, ~8 Mt of green hydrogen will be needed, which is equivalent to all of Europe's current hydrogen demand. Additionally, approximately 550 TWh of renewable electricity will be needed, equivalent to 1.2x that of France's current annual electricity consumption[2].

Impact of the recommendation: deploying SAFs to the levels outlined in ReFuelEU Aviation, if achievable, will help cut the sector's total warming impact on the planet by ~38% by 2050.

[2] Future Cleantech Architects will publish a technical assessment of ReFuelEU in the second quarter of 2024. Numbers for PtL production are based on the Fischer-Tropsch synthesis optimized for jet fuel production.

5. Tackle aviation's non-CO_2 emissions head-on, especially contrails

More than 60% of aviation's impact on global warming comes from non-CO_2 emissions, with contrails making the largest contribution (>50%). To truly minimize aviation's impact on the environment, non-CO_2 emissions, particularly contrails, must be addressed simultaneously with CO_2 emissions.

- Measures to mitigate contrails must be solely targeted at flights that are susceptible to contrail formation, which make up only ~10% of all flights. Monitoring, Reporting, and Verification (MRVs) of non-CO_2 effects must be included in the legislation, particularly for monitoring contrails, under a common methodology.

- Flight rerouting is the method with the highest leverage to mitigate contrails (see Box 5 and Fig. 3 for an illustration). This method has already been proven feasible by EUROCONTROL in 2021. The current EU implementing regulation on Air Traffic Management (ATM) must expand to include a clear framework on flight rerouting for contrail avoidance. Revisions of the Single European Sky must also prioritize contrail avoidance and develop a clear flight rerouting framework across the EU.

- Continued investment and R&D (see recommendations 2 and 3) into weather monitoring systems and the use of Artificial Intelligence is necessary to improve the prediction accuracy of Ice Super Saturated Regions (ISSRs), the regions where contrails are prone to form during a flight. These improvements will help guide and automate rerouting efforts and increase their effectiveness.

Rerouting flights

Box 5

In 2023, a study by Breakthrough Energy, American Airlines, and Google Research on altering flight routes found a 54% reduction in contrails at an added cost of 2% of fuel per deviated plane. As only a small percentage of flights need to avoid ISSRs, this amounts to a minimal added 0.3% fuel cost across an airline's total flights.

- SAFs as low aromatic content fuels[3] can help reduce contrails, because aromatic content is linked to soot formation, which in turn is linked to contrail formation. Aviation fuel used today far exceeds the minimum safety limit of 8% aromatic content. Blending with SAFs will naturally bring down the aromatic content of the fuel and thus help in reducing contrails. As SAFs are still a scarce commodity, ReFuelEU Aviation should also include provisions prioritizing SAFs for contrail-prone flights.

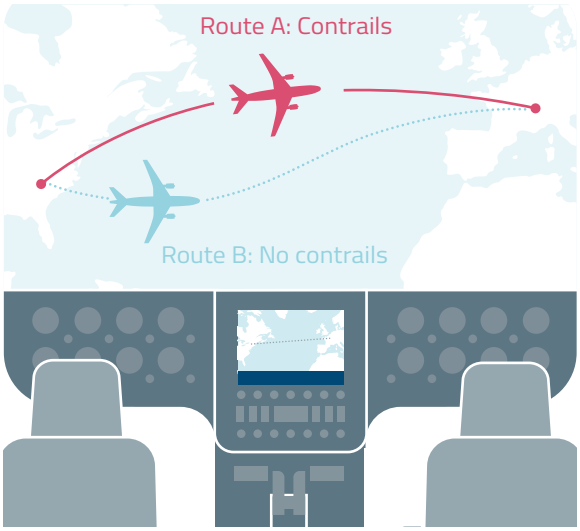


Figure 3. Illustration of flight rerouting to avoid contrails where route A passes through an ISSR and forms contrails while route B avoids the ISSR and does not form contrails.

Impact of the recommendation: As we saw in recommendations 3 and 4, ambitiously deploying all-electric, hydrogen and SAFs together could reduce aviation's total warming impact by 55% by 2050. Additional contrail avoidance measures will help cut the sector's total warming impact by another 15%. The combined impact of these measures is a total 70% reduction by 2050. Remaining warming impact is associated with upstream and other non-CO_2 emissions.

[3] Aviation fuel used today is made up of a combination of hydrocarbons, with aromatics making up on average 15%-20% of the fuel's composition by volume.

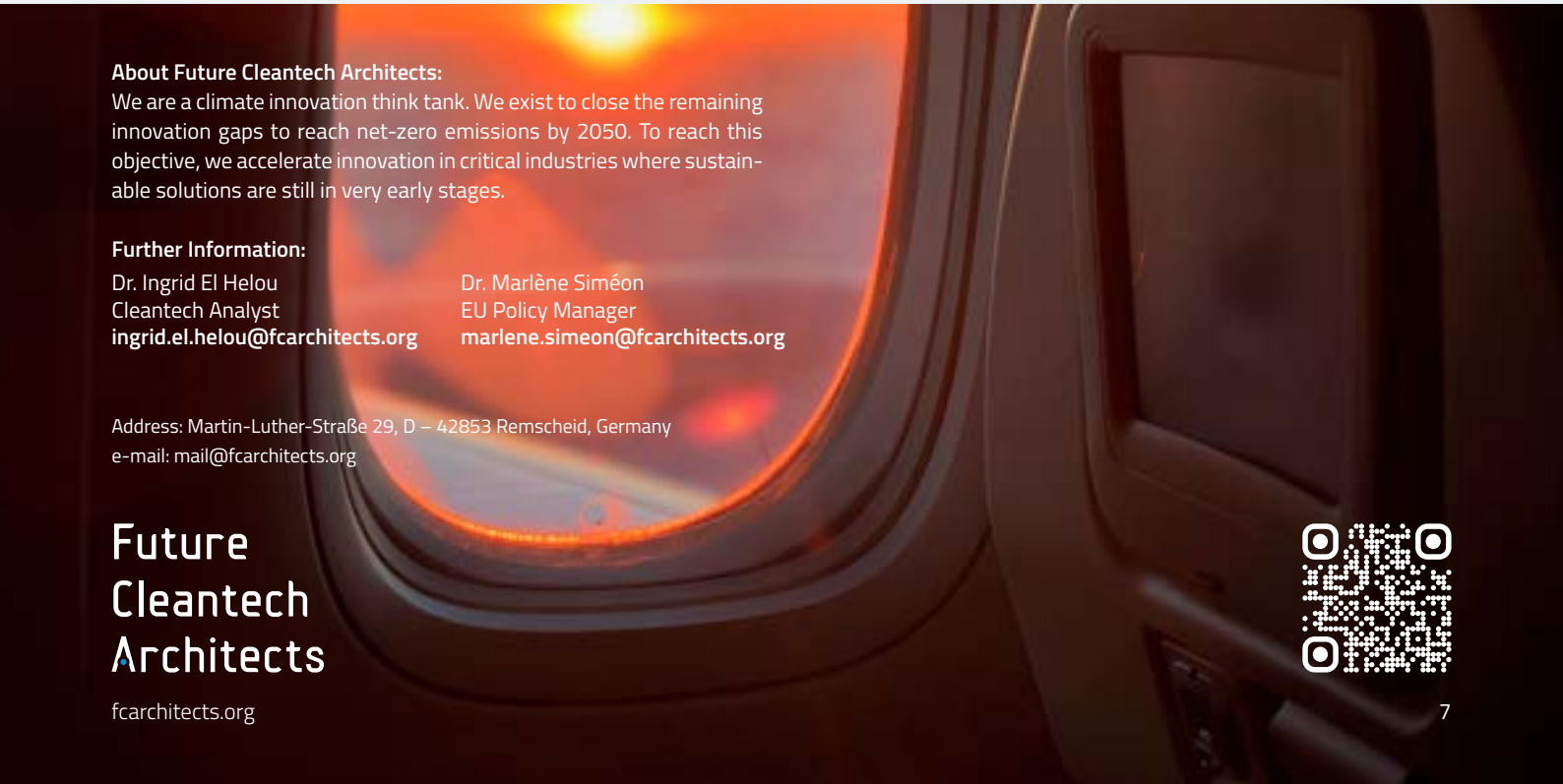
Conclusions

Immediate action is needed to ensure emissions decouple from growth past 2030 and achieve true net zero by 2050. Current measures are not enough to decarbonize the aviation sector in the EU. The following steps for European institutions provide a framework to get the sector on track with European sustainability goals:

- Ensure and monitor the swift implementation of legislative frameworks agreed on in 2023, including ReFuelEU Aviation, the Renewable Energy Directive, EU ETS, the AFIR, and the TEN-T revised guidelines.
- Make sure that investments from new EU ETS allowances help advance all-electric and hydrogen powered aircraft where they can be deployed, ramp up SAF availability, and derisk innovation such as the development of novel aircraft designs.
- Restart discussions on the Energy Taxation Directive to immediately address aviation fuel taxation, which, if correctly reinvested into innovative solutions, will offer a major additional source of revenue for the sector's transformation.
- Adopt a common methodology for monitoring, reporting, and verification of non-CO_2 effects and revise the Single European Sky to prioritize contrail mitigation measures.
- Rigorously monitor these regulations' impact on the sector's CO_2 and non-CO_2 emissions and regularly update them based on their effectiveness and the newest scientific evidence.
- Make sure insurgent innovators, scientific think tanks, and Member States are represented in the Alliance for Zero-Emission Aviation to enhance the interplay between on-the-ground feedback, scientific evidence, and policymaking.

Future Cleantech Architects advocates for the adoption of the following measures to facilitate the transition to a sustainable aviation future:

1.	2.	3.	4.	5.
Foster robust alternatives to short-haul flights	Leverage carbon pricing for a sustainable aviation transformation	Invest heavily in research, development, demonstration, and innovation	Introduce ambitious, yet realistic, SAF mandates with clear sub-targets for PtL fuels	Tackle aviation's non-CO_2 emissions head-on, especially contrails
Shifting 17% of short-haul (<1500km) flights to rail will help cut 5% of emissions from the sector	In 2022, European governments could have earned €34.2 billion in tax revenue and invested it in innovation	Deploying all-electric and hydrogen aircraft on flights <4000 km by 2050 will help cut the sector's total warming impact by 17%	Achieving ReFuelEU's 2050 target of 70% SAFs in the fuel mix by 2050 will help cut the sector's total warming impact by 38%	Implementing all-electric, hydrogen, SAFs, and contrail avoidance in combination by 2050 will help cut the sector's warming impact by 70%



About Future Cleantech Architects:
We are a climate innovation think tank. We exist to close the remaining innovation gaps to reach net-zero emissions by 2050. To reach this objective, we accelerate innovation in critical industries where sustainable solutions are still in very early stages.

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