How can we make aviation green?

Key points

- Aviation is committed to decarbonise and to achieve the net-zero goal by 2050 - there is no simple solution but it will require a massive collaborative effort and innovations.
- There is a substantial energy problem from renewable sources affecting not only aviation but also other industries and modes of transport.
- Additional stimulus to promote, fund, and commercialise the transformation is required and there is a need to ensure that aviation gets its share.
- With only 26 years left until 2050, there is a pressing need to accelerate efforts.

Not so long ago our world was more colourful but today everyone seems to want to be "green". However, the needed environmental transformations often require substantial and costly changes. From a marketing point of view, there is a temptation to simply greenwash initiatives.

In our most recent Performance Review Report [1], we have some interesting observations about the environmental performance of European aviation in general and the contribution of air traffic management (ATM) toward achieving the ambitious environmental goals. What's the current state of the evidence and what would be our current answer? Let's have a closer look.

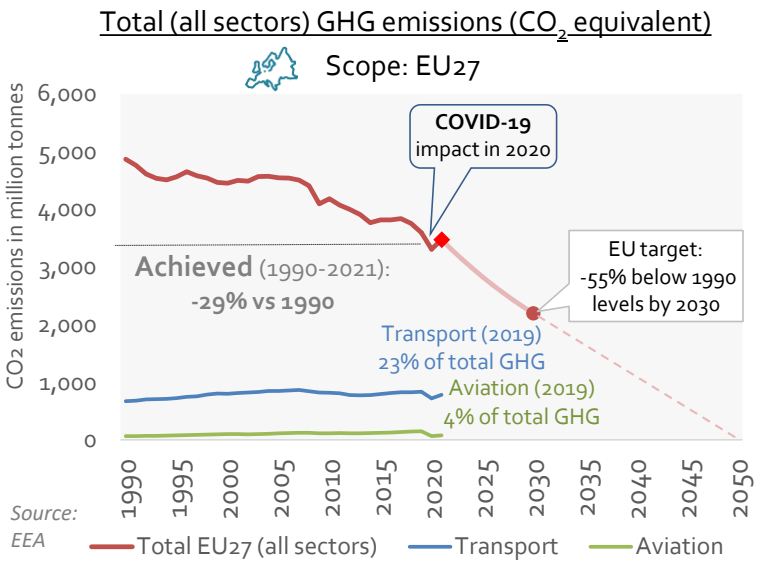
What is the ambition?

The Paris Agreement sets global targets for reducing emissions to limit global warming, while the European Green Deal outlines specific measures and policies to achieve carbon neutrality in the European Union by 2050. As an intermediate goal, the European Green Deal aims to reduce emissions by at least 55% compared to 1990 levels by 2030.

The aviation industry now collectively strives towards the common global goal of achieving net-zero carbon emissions by 2050.

For the transport domain, the European Green Deal calls for a 90% reduction in GHG emissions by 2050 compared to 1990 levels, while working towards a zero-pollution ambition.

In Europe, aviation accounted for approximately 4% of total greenhouse gas (GHG) emissions before the COVID-19 pandemic.



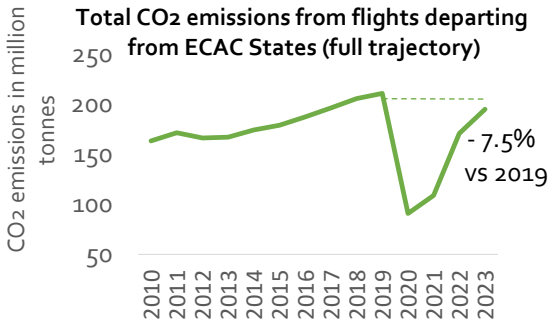
While this proportion of 4% may seem relatively small, it is expected to increase in the future. As aviation is challenging to decarbonise, other sectors are anticipated to decarbonise more easily over time if sufficient energy from renewable, clean sources can be made available.

Are we on track?

In the past two decades – wind and solar power have taken off, faster than experts ever expected and at the same time consumption started to decline largely thanks to improved energy efficiency. Part of the emission reduction was also due to the outsourcing of heavy industries outside the EU.

For aviation, our analysis shows that the COVID-19 pandemic was only a temporary break.

CO2 emissions from European aviation increased again in line with traffic recovery and are likely to grow back to pre-pandemic levels soon.



Despite the efficiency gains made to date, the observed pace suggests that there is a need to speed up efforts substantially to be able to achieve the ambitious environmental targets by 2050.

To support stakeholders in their decarbonisation efforts, EUROCONTROL has set up the "Flying Green" platform offering a wide variety of tools and information in support of the transition from fossil fuels to sustainable aviation [2].

But why is it so difficult to decarbonise aviation?

In simple terms, at the heart of the decarbonisation problem is the need to find a safe, cost-effective, and reliable alternative to fossil fuel with the energy density needed to provide the power for flight.

Aircraft need to be lightweight to achieve optimal fuel efficiency. Alternatives to power commercial aircraft with batteries or other alternative non-fossil propulsion systems (hydrogen, etc.) are years if not decades from industrialisation. The first electric aircraft was certified by EASA in 2020 but current battery technology make it only a viable solution for small aircraft with a limited range.

Particularly for long haul flights which generate by far the main share of the emissions there are no alternative modes of transport available [3]. Just under 10% of flights in Europe are long haul flights but generate over 50% of total aviation CO2 emissions.

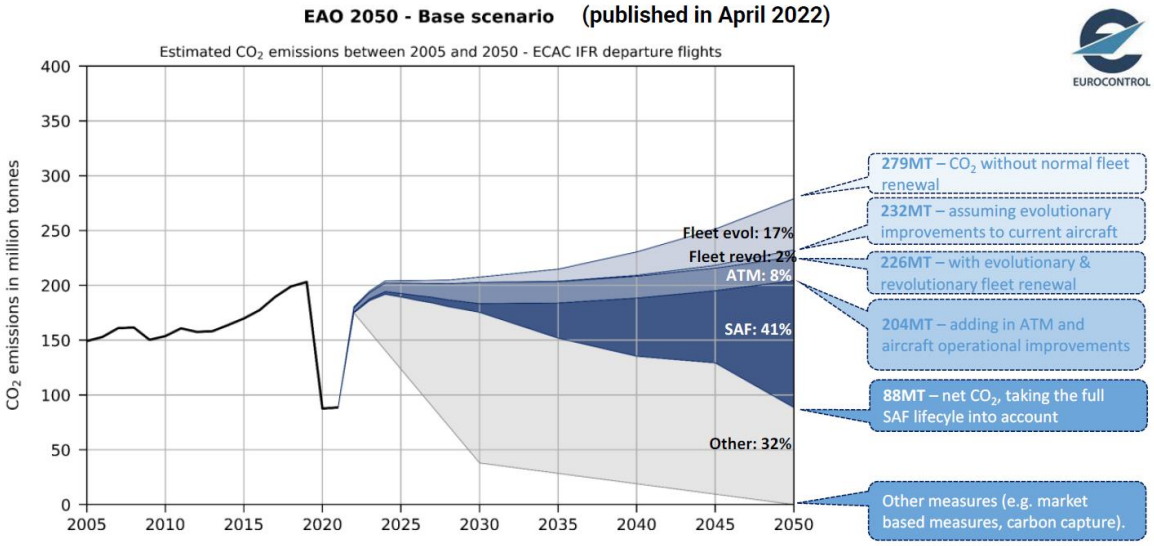
Small hydrogen powered aircraft might be introduced in the mid-2030s but for larger aircraft this will require a complete redesign to address the characteristics of liquid hydrogen. In general, new technologies in aviation require long lead times due to the high safety standards and certification processes. With a typical aircraft lifespan of 20-30 years, it will take time until efficiency gains through fleet replacements will fully filter through the entire aircraft fleet[1].

[1] *The first delivery of the newest Boeing derivate the B777-8/9 is planned for late 2025. Boeing announced that model in 2013 (so it required twelve years till entry into service). And it is not a new model, it is a derivate of existing structure unveiled in the mid 90's. And there was no revolution in the type of propulsion to be certified.*

So what are the options?

The aviation industry is committed to decarbonise but there is unfortunately no simple panacea or silver bullet for reducing aviation's impact on climate. While everybody acknowledges the immense challenge of achieving the aviation industry's net-zero goal by 2050, there are a wide variety of opinions how this can be achieved.

Essentially all projections incorporate four complementary pillars, but they diverge in terms of the contributions from each area: (1) aircraft technology (airframes and engines), (2) sustainable aviation fuel (SAF), (3) market-based measures (MBM), and (4) enhanced infrastructure and operations.



Many models, including the latest EUROCONTROL Outlook 2050, consider the uptake of sustainable aviation fuel (SAF) as the main driver to achieve the zero net emissions goal. SAF can be produced in different ways. Biofuels are derived directly from biomass, synthetic fuels are based on converted carbon-based feedstocks, and power-to-liquid fuels use renewable energy to produce synthetic hydrocarbon fuels from water and CO2. The main problem is the need for renewable resources and energy which currently make the SAF production process cost intensive while at the same time competing with other decarbonising industries. For instance, all biomass waste available in Ireland would only allow to replace about 4% of fossil fuels consumed by the country [4]. A common denominator is that all these solutions would require huge amounts of energy from renewable sources.

Today, SAF is approximately 3 times more expensive than fossil fuel [5] and the uptake in Europe is still below 2% but is required to grow to 6% by 2030 in EU States, according to the Fitfor55 Package [6]. **Considering the progress to date (less than 2%) and the financial and energy resources required, reaching the anticipated milestone of 6% SAF uptake by 2030 will require a major acceleration of efforts.**

Where aviation will be unable to reach the net zero target operationally, Market Based Measures will have to complement technological innovation and operational improvements in the transition towards a more sustainable aviation industry. There is a vast portfolio of possible economic measures including, global or regional emission trading schemes, specific taxes on fuel or tickets, or the application or adjustment of charges to incentivise the decarbonisation of aviation.

The EU emissions trading system (EU ETS) and ICAO's Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA) schemes encourage airlines to reduce CO2 emissions. The EU ETS is a "cap and trade" scheme and CORSIA is an "offsetting" scheme implying that emissions can grow if they

are compensated by projects that remove or reduce greenhouse gases elsewhere such as reforestation or similar projects. Although still in its early stages, the use of carbon removal technologies to compensate for emissions from fossil fuels could offer a potential cost-effective solution to be added to the basket of solutions for aviation to contribute towards the climate goals.

Aircraft technology is another pillar expected to help mitigating CO_2 emissions. Innovative aircraft technology (aircraft design, propulsion systems, engine efficiency, aerodynamics) has significantly increased fuel efficiency over the past decades. While it's true that substantial efficiency gains in recent years [7] and increased use of new generation aircraft have reduced the environmental impact of aviation, these relative efficiency gains per passenger mile have not been sufficient to offset the additional growth in air traffic.

Alternative propulsion systems could substantially shift the balance toward the net-zero goal for short- to medium-haul flights. The Alliance for Zero-Emission Aviation (AZEA), a voluntary initiative of private and public partners, has just launched its vision which sets an ambitious objective of having 36 to 68% of intra-EU flights operated by hydrogen- and electricity-powered aircraft by 2050. The total renewable and low carbon energy required to operate those flights in 2050 is estimated to correspond to 1.1 to 2.8% of the gross electricity generation foreseen by 2050 [8].

As for all other transport sectors, a common theme among the proposed solutions to achieve the net zero target in aviation is that the main contributing measures will require significant time, substantial resources, ample financing, or (most likely) a combination of all three.

But is there anything that can be done now?

With benefits from aircraft technology and SAF only taking real effect beyond 2030, ATM has a significant role in reducing emissions by addressing operational inefficiencies in the ATM system already in the short to medium term. For every tonne of fuel saved, an equivalent amount of 3.15t of CO_2 can be avoided.

ATM deploys a number of initiatives aimed at improving operational efficiency, including performance-based navigation (PBN), free route airspace (FRA), Flexible Use of Airspace (FUA), continuous climb and descent operations (CCO/CDO), and other solutions. These initiatives are supported by a communications, navigation and surveillance (CNS) infrastructure which can be seen as an enabler of aviation operational performance.

The latest estimates suggest that the ATM related "benefit pool" is around 9-10% of the total gate-to-gate fuel burn (emissions) in the European Civil Aviation Conference (ECAC) area. There is clearly scope for further improvement in ANS operational performance. However, it is important to stress that the often-quoted benefit pools cannot be fully recovered (e.g. operational safety or military requirements) nor can the inefficiencies be entirely attributed to ANS (e.g. adverse weather).

Additionally, ATM may be asked to play a role in reducing the non-CO_2 impact of aviation for which the scientific community is gathering evidence. Navigational avoidance of persistent contrails remains challenging due to the difficulty in accurately forecasting ice-supersaturated regions (ISSR) in terms of both time and location and will require additional capacity. Rerouting aircraft based on inaccurate forecasts can result in even higher CO_2 emissions from increased fuel burn, potentially failing to avoid contrail formation if an ISSR exists along the new route.

Even though it will be challenging to cut the ATM-related inefficiencies by half in a context of increasing traffic, the key difference compared to the other measures is that ATM can start already now to address efficiency constraints with the achieved environmental benefits cascading up to 2050.

So. Will aviation ever be green?

The aviation industry has committed to decarbonise by 2050.

As with all energy-intensive industries and other modes of transport, a key factor in achieving environmental goals will be the availability of sufficient energy from renewable sources. Because of the high energy density needed to power aircraft and the rigorous safety requirements, aviation is one of the most difficult sectors to decarbonise. This will most likely lead to an increase in the relative share of total aviation-related CO_2 emissions in the short term, as other industries will be able to decarbonise more easily and quickly.

ATM can help reducing CO_2 emissions already now but will not be the main factor to achieve carbon neutrality. Nonetheless, the efficiency gains realised today will cascade and accumulate over the coming years developing a substantial environmental benefit. ATM can furthermore help mitigating non-CO_2 effects from aviation, provided that the overall climate impact of a flight is understood sufficiently to take the necessary actions.

With SAF production levels remaining comparatively low and aircraft manufacturers struggling to meet the demand for greener aircraft, significant benefits are expected only after 2030. The challenges related to renewable resources and energy required are enormous, while aviation is simultaneously racing against other decarbonising industries.

The ReFuelEU Aviation initiative, as part of the Fitfor55 Package, is a good stimulus for the required transformation as it introduces a SAF blending mandate gradually scaling up the use of SAF for departing flights, from less than 2% today to 6% in 2030 and 70% in 2050 [6]. However, given the magnitude of the challenge and the urgency of the required changes to achieve the set targets, additional incentives to promote, fund, and commercialise SAF production are likely to be necessary to narrow the price gap between SAF and fossil fuel. Market based measures are likely to be needed to expedite the transition and bridge the remaining gap toward the goal of net zero emissions by 2050.

Even though the industry is now collectively striving towards a common goal to mitigate the impact of aviation on the climate, with only 26 years left until 2050, there is a pressing need to accelerate efforts. Given the current trends and speed of change, it will be a herculean challenge to make aviation "green" and to achieve the ambitious aviation net zero targets unless there is a dramatic change in action starting soon.

To ensure sufficient stimulus, environmental revenues from aviation could be used to support the decarbonisation of the aviation industry but also to invest in promising potentially less costly alternatives such as carbon removal and storage.

For sure the transformation will require innovations (e.g. 26 years ago there were no iPhones nor Google) and collaboration among all industry stakeholders, government support, and researchers to develop and deploy the most suitable solutions while ensuring safety, reliability and affordability.

Last but not least this will also require the passengers to accept that the transformation will not be for free. According to many airlines, passengers declare that they care about the environment; however, fewer than 5% are willing to pay extra to offset their flight's emissions.

So, how can we make aviation green? The entire aviation industry is already working hard towards achieving the net zero target by 2050. However, to meet this ambitious target, a major acceleration of current activities is necessary and will require large amounts of green energy in competition with many other areas of industry.

BACKGROUND

This publication has been produced by the Performance Review Commission (PRC). The PRC was established by the Permanent Commission of EUROCONTROL in accordance with the ECAC Institutional Strategy 1997. One objective of this strategy is "to introduce a strong, transparent and independent performance review and target setting system to facilitate more effective management of the European ATM system, encourage mutual accountability for system performance…"

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