LibMod Policy Paper
January 2021

A Roadmap Towards Climate-Neutral Aviation

by Ralf Fücks,
Matthias von Randow,
and Volker Thum

LIB MOD
Zentrum
Liberale
Moderne

Contents

About the authors

Ralf Fücks is managing partner of the Zentrum Liberale Moderne. Matthias von Randow is Chief Executive Officer of the German Air Transport Association. Volker Thum serves as Chief Executive Officer of the German Aerospace Industries Association.

We would like to thank Lukas Daubner, research assistant at the Zentrum Liberale Moderne, for his valuable support.

Cover image: Adobe Stock / fotofabrika

Preface

The air transport industry, science, and politics widely agree on the great potential for climate-neutral air travel.

Air travel is the transport infrastructure of our globalized world – a physical *world wide web*. It enables personal encounters across national borders. It makes politics, business, science, culture, and sports more international. It is also the means of transport of global tourism. Migrants visit their families, students use opportunities for international exchange, and non-governmental organizations also network globally. Video conferences and video chats can only ever be partial substitutes for face-to-face encounters.

Until the COVID-19 pandemic caused a dramatic drop in passenger numbers, plunging the aviation industry into dire crisis, the evolution of passenger numbers knew only one direction: upwards. Between 2013 and 2018, aviation volumes in the European Union increased by 26 percent. In 2019, about 4.5 billion passengers travelled by air worldwide, a figure that was projected to double to about 9 billion by 2040.

The COVID-19 crisis caused an unprecedented collapse of air traffic. A large portion of European airlines are currently in the red. The industry's financial strength is waning. Demand for new, more environmentally friendly aircraft has plummeted drastically, which heightens the urgent need to promote climate-friendly innovations in air transport within the framework of the "European Green Deal" and other government programs.

It is virtually impossible to predict with any degree of reliability how quickly aviation will recover from the COVID-19 crisis and how it will evolve in the future. From a global perspective, however, demand for air transport will grow again. With rising incomes in developing countries and their integration into the global economy, private and commercial air travel will increase in the long term. A growing global middle class also means a growing number of potential air passengers.

This is why it is so important to make air travel climate-neutral. Today, air traffic is causing about three percent of global CO_2 emissions. Its actual contribution to the greenhouse effect, however, is greater due to additional climate effects (nitrogen oxides, water vapor, etc.). The IPPC puts the contribution of aviation to total greenhouse gas effects at up to five percent. Given the global trend, radically restricting air traffic is not a realistic option. It might be discussed in a country like Germany. It is not even up for debate in China, India, the US, and aspiring developing countries.

At the same time, however, aviation – like all other economic sectors – has committed itself to the goal of climate neutrality. This move towards climate-neutral air travel offers great opportunities for Germany and Europe to become pioneers of a future industry, from aircraft construction and propulsion technology to the production of climate-neutral fuels at an industrial scale.

In this context, the Zentrum Liberale Moderne, the German Air Transport Association (BDL) and the German Aerospace Industries Association (BDLI) held a series of talks with members of the German Bundestag, representatives of federal and state ministries, and scientific experts throughout 2020. Our focus was on avenues towards climate-neutral air travel and the political course we need to set to attain this target. The following is a summary of our key takeaways from this series of talks, our "Roadmap Towards Sustainable Air Travel".

Our key finding is that making air travel compatible with climate protection is a realistic goal. There is a broad consensus between the aviation industry, science, and politics on the potential for climate-neutral air travel. The question is no longer "whether", but "how", i. e. with which concrete measures and instruments, we can reconcile climate policy goals with a functioning international aviation system.

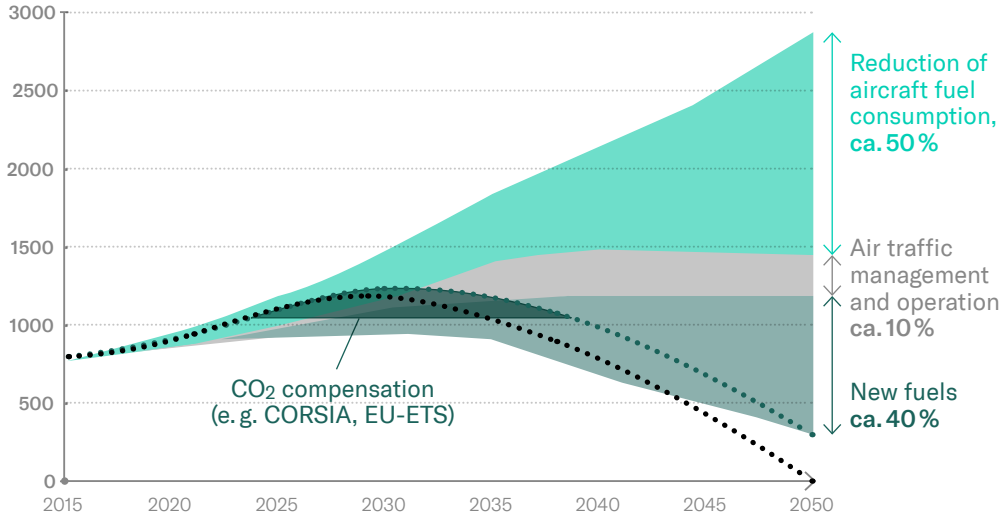
I. Intermediate steps and timeline for climate-neutral air travel

The propulsion technologies, fuels, design features, and flight control measures required for climate-neutral air travel are no elusive mirage. There are four basic approaches to drastically reduce the climate impact of air travel:

- Compensate air traffic emissions by trading emission certificates as well as via offset projects (CO_2 savings in other sectors where they are feasible in the short term.
- More efficient flight management (climate-friendly flight routes and altitudes, Single European Sky).
- Continuously develop energy-efficient aircraft (aerodynamics, lightweight construction) and engines (optimization).
- Develop alternative propulsion technologies and sustainable fuels (leap innovations).

In the long term, up to 50 percent of CO_2 emissions can be avoided thanks to more efficient aircraft and engines. Another 10 percent can be cut with intelligent air traffic management, and approximately 40 percent by using climate-neutral fuels. However, we are going to run into conflict between short- and medium-term climate policy timelines and the typical innovation cycles in air transport. Development and approval of new aircraft and propulsion systems and the subsequent renewal of the fleet take a long time. Major leaps in innovation are not expected before 2030.

Global CO_2 reduction targets and drivers of change

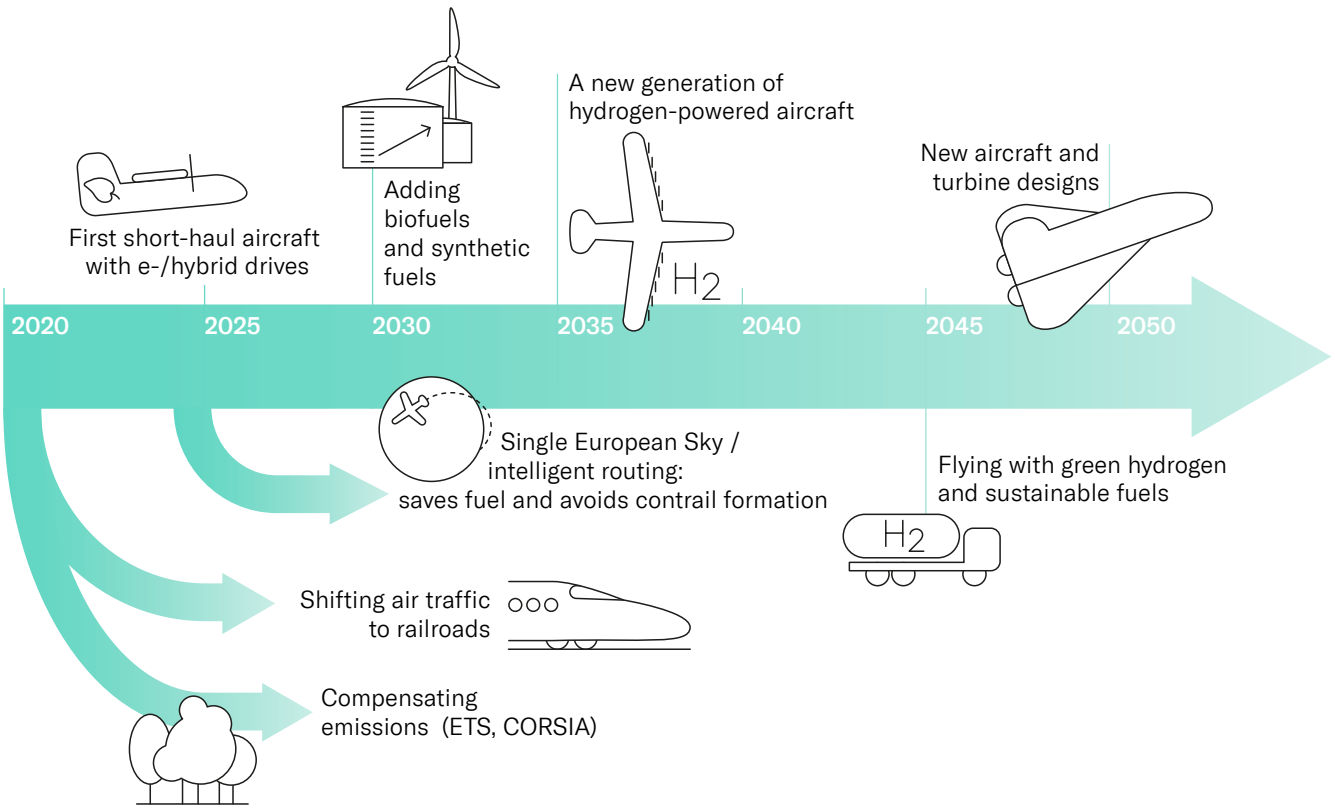


Key areas:

- Hybrid-electric and all-electric designs
- Disruptive technologies for hydrogen-powered aircraft
- Ultra-efficient aircraft

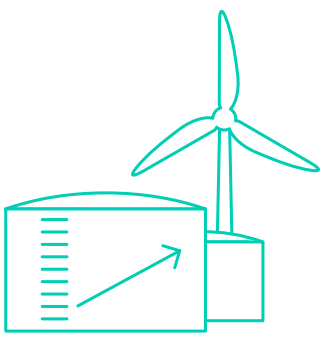
Source: IATA / CLEAN SKY presentation at the #AeroDaysFORUM, Berlin, Nov. 2020

The future of air travel



If we were to maintain current innovation cycles, reducing aviation-related greenhouse gas emissions to near zero would take us well into the second half of the century. As long as the goal of climate neutrality cannot be achieved by technical innovations alone, even with accelerated innovation cycles, additional compensation mechanisms such as emissions trading or the CORSIA agreement will be indispensable. However, they are no substitute for reducing the actual greenhouse gas emissions generated by air traffic.

Establishing a hydrogen infrastructure and financing pilot plants to facilitate a historically fast transition to climate-neutral air travel will not be possible without government support for research and development. In addition, we urgently need a reliable regulatory framework for the companies' costly long-term investments towards climate neutrality. We need regulatory measures to avoid distortions of competition and the associated risk of "carbon leakage".



II. What does it take to make climate-neutral air travel possible?

New aircraft and engine designs

Since the early days of human flight, aircraft design, technical systems, and engine technology have never ceased to evolve, becoming more powerful and more efficient all the time. New lightweight materials and improved aerodynamics can help make aircraft more economical in the future, as well. Each new generation of aircraft requires up to 25 percent less kerosene. Since 1990, CO_2 emissions per passenger kilometer have dropped by 43 percent. However, these efficiency gains have been eaten up by volume growth in air traffic. The next generation of engines, which will be deployed from 2030 onwards, is expected to be another 25 percent more efficient and 50 percent quieter. Reducing fuel consumption per passenger and flight kilometer is vital, since in the long term, it will also reduce the amount of required climate-neutral fuels.

However, the development and market penetration of new, eco-efficient aircraft is anything but peanuts. Development costs for a new generation of aircraft and engines, for instance, amount to approximately 50 billion euros. In the past, it took about 15 years to develop and approve new aircraft designs and engines, with market penetration (fleet renewal) taking another 25 to 30 years. In the interest of climate protection, these cycles must be shortened considerably, which will require a substantial increase in public and private investment in research and development as well as accelerated development cycles and approval procedures.

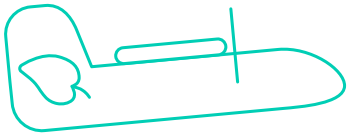
New fuels are essential to achieve climate-neutral air travel.

Use of sustainable (especially synthetic) fuels

New fuels are essential to achieve climate-neutral air travel. Great hopes are pinned on electricity-based fuels and advanced biogenic fuels. Both offer the advantage that they can already be added to kerosene as so-called drop-in fuels to the tune of up to 50 percent. Another possible alternative is the direct use of climate-neutral hydrogen as aircraft fuel. Airbus, for example, has announced that it will develop and put into operation an emission-free aircraft by 2035, which will most likely be powered by hydrogen. All alternative fuels still require research into their climate impact beyond CO_2.

The availability of biogenic fuels from renewable raw materials is limited by the scarcity of arable land and potential competition with food production for a growing world population. A possible supplement is a new generation of biofuels derived from cellulose and organic waste. Another option is algae-based fuel, which requires considerably less surface to produce. One advantage of biogenic fuels is that they can be blended with conventional aviation fuel and thus contribute to reducing CO_2 emissions in the short term.

The use of hydrogen as a propulsion fuel requires com-plex changes in aircraft concepts as well as airport infrastructure. Ramping up production capacities for climate-neutral hydrogen will take well into the 1930s. Furthermore, there is a need for research on the climate impacts of direct combustion of hydrogen, in particu-lar with regard to water vapor emissions. For all these reasons, it is necessary to promote the production of renewable synthetic fuels. They can be added to conven-tional kerosene, which will enable a gradual substitution of fossil fuels in ongoing aviation operations. A potential advantage of Sustainable Aviation Fuels (SAF) is their virtually particle-free combustion, which also reduces the formation of contrails.



The main obstacles are the high demand for electricity and significantly higher production costs of synthetic fuels, which are obtained from other energy sources through complex chemical processes (PtL — Power to Liquid). However, this process will only help protect the climate when it is based on electricity from renewable sources.

At present, we are still in the very early stages of converting flight operations to sustainable fuels. So far, only a few SAF test facilities exist in Germany. Sustainable hydrogen is expected to remain scarce and comparatively expensive well into the 2030s. Combined with increasing demand for hydrogen and synthetic fuels in other sectors, we will need far greater amounts of renewable electricity, which will require an international renewable energy network.

Digitalization of planning and manufacturing processes

Digital modelling of new aircraft and engine components and their flight behavior can accelerate their introduction, reducing both CO_2 and costs. Increased use of sensors, 3D printing, or augmented reality will play a major role in future aircraft production and maintenance. The properties of new materials as well as changes to individual parts or entire components can be tested, modified, or discarded in a digital environment.

In addition to digitalizing planning and production, manufacturers are also focusing on robotics to increase automation. Digital coordination of supply chains can further optimize manufacturing and delivery.

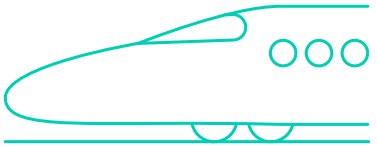
Maintenance offers another opportunity for efficiency gains. Technical systems that automatically indicate maintenance or repair needs can both help conserve hardware and optimize maintenance processes (*predictive maintenance*).

Compensation of CO_2 emissions

As long as we cannot achieve climate neutrality by technical innovations alone, we need tools for compensation. In particular, this includes CO_2 emissions trading. The sale of emission certificates can facilitate CO_2 reductions in other areas, where it is already technologically possible, but has not been financially viable. Emissions trading combines the gradual reduction of emissions, as required by climate policy, with the advantages of market-based price control.

The EU tried and failed to include air travel in international emissions trading with third countries. However, the fact that the international community has decided to include international air traffic in the CORSIA CO_2 compensation plan from 2021 is a step forward. The purpose of this system is to compensate growth-related emissions in aviation both through efficiency gains and offsets (CO_2 savings in other sectors). The aim is to keep the growth of international air traffic CO_2-neutral. The system is financed by airlines that purchase compensation certificates. Its acceptance depends on transparent sustainability criteria and independent monitoring of the offset projects.

In addition, passengers can compensate for the climate effects of their own flights by paying surcharges, which are used to finance projects to reduce greenhouse gas emissions. However, only few passengers are currently taking advantage of this option. It would make sense to integrate carbon compensation options into the booking process, as it may increase the passengers' willingness to pay a moderate surcharge for climate protection.



Improved flight control

Both optimized flight routes and altitudes play an important role in the climate impact of air traffic. Flying detours is counterproductive, as is flying in damp and cold air layers, in which contrails linger for a particularly long time. More research on the climate impact of contrails is needed as they can contribute significantly to global warming. At the same time, research indicates that they might also have cooling effects on the atmosphere. The formation of contrails can be reduced by climate-optimized flight routes, for example by deliberately avoiding regions that are oversaturated with ice. However, such detours would often lengthen the flight distance and thus increase fuel consumption. Detours are also limited by airspace capacity.

The bottom line is that by avoiding holding patterns, optimizing flight routes and altitudes, and optimizing air traffic control organization in the European airspace, we could avoid 5 to 10 percent of today's air traffic-related CO_2 emissions and reduce water vapor emissions and the formation of contrails.

Move more traffic to railways

Another opportunity to reduce climate-damaging emissions is to shift traffic to railways. Ideas range widely, from shifting short-haul flights to rail entirely to the conclusions of a potential analysis by the air transport industry, which found that approximately one fifth of domestic German air traffic could be shifted to rail. To achieve even this more modest objective, railway operators must offer more frequent train services, shorter journey times, and improved luggage transport and reliable connectivity in transfer traffic.

Climate-neutral airport operation

German airports are already working on comprehensive concepts for climate-neutral airport operations. These include switching to renewable energies, making buildings energy-efficient, converting the vehicle fleet to electric, and avoiding or recycling waste.

Germany is in a good position to become a leader in developing technologies for climate-neutral air travel.

III. What can politics and other actors do?

Promote research and development

Germany, with its innovative big industry, highly specialized medium-sized companies, agile start-ups, and renowned research institutions is well positioned to play a leading role in developing technologies for climate-neutral air travel – from aircraft to propulsion technology and fuel. In addition, Germany entertains partnerships with European neighbors and global partners.

The potential is there. Close cooperation between all players is essential to exploit it. This applies, in particular, to the transfer of knowledge between research and industry. Governments can support this innovation network with targeted funding – for example, for SAF pilot plants and tech pioneers. Research programs should involve more small and medium-sized enterprises and start-ups.

Support fleet renewal

Continuous fleet renewal with more energy-efficient aircraft helps reduce greenhouse gases. Funding under the European Green Deal is available for replacing obsolete aircraft with energy-efficient new machines. This approach will need WTO-compatible solutions. As air traffic ground to a halt due to the COVID-19 pandemic, so has fleet renewal. In this context, the German government's support program is a great contribution to help convert fleets to more environmentally friendly planes despite the COVID-19 crisis. Other incentives for fleet renewal include increasing CO_2 prices in international aviation, higher emission and noise standards for take-offs and landings in the EU, and improved tax write-off options for low-emission aircraft.

Single European Sky and climate-efficient flight routes

While the climate effect of carbon dioxide has been exhaustively studied, there is still a need for research on non-CO_2-related effects. This also applies to the question of avoiding contrails and cirrus clouds in practice. We therefore welcome the cooperation between German Air Traffic Control with the airlines, the German Aerospace Center, and the German Meteorological Service to find ways to avoid climate-damaging emissions in practice.

Route optimization in the European airspace is known under the term "Single European Sky". In Europe, the "Free Route Airspace" has saved more than 2.6 million tons of CO_2 since 2014. That is around half a percent of all CO_2 emissions caused by air traffic.

However, we see a need for further action at European level:

1. Greater automation of traffic control services using standardized technologies.
2. More flexible deployment of air traffic controllers so they can work in more than one sector.
3. EU-wide standards for air traffic control technologies, procedures, and licensing.
4. Technologically optimized procedures to reduce emissions during landing, avoid unnecessary flight paths, and shorten taxiing distances on the ground.
5. Fewer detours required to avoid restricted military areas – also outside of Germany.

The recently presented proposals by the EU Commission address these fields of action only sporadically. Here, further improvements must follow.

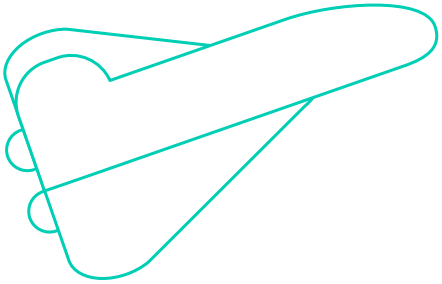
Make fossil fuels more expensive, create incentives for SAF, ensure neutral competition, avoid price dumping

Air transport is a global industry involving numerous, competing international players (airlines, manufacturers, airports). Unilateral national efforts are therefore caught in a predicament between good intentions and ineffectiveness. There is nothing to be gained for the climate if national taxation ends up merely shifting CO_2 emissions to other world regions where these regulations do not apply (carbon leakage), while also placing a one-sided burden on the country's own domestic airlines and airports. Regulation of air transport is most effective when it is done internationally or at least at European level.

It is crucial to take determined steps. The future starts now.

In our view, these are the cornerstones of a regulatory framework for climate-neutral air travel:

- The emissions trading system must be expanded and also include connecting flights to hubs outside the EU.
- The German Federal Government should advocate for standardized aviation taxes in the EU. Revenues should be used to promote a system change from fossil kerosene to sustainable aviation fuels, e. g. by offering compensation for the additional costs of blending sustainable fuels as long as it is only mandatory at the national or EU level.
- Sustainability criteria need to be incorporated into the CORSIA CO_2 pricing system, which applies to international aviation. The next step should be to price not only growth-related emissions, but also existing ones to better reflect environmental costs in air fares while also compensating climate-harmful emissions as long as climate-neutral air travel is not yet possible.
- A gradually increasing blending quota for Sustainable Aviation Fuels is an effective instrument to "upscale" sustainable aviation fuels and successively substitute fossil kerosene. It should apply to the entire EU, if possible. This will create stable demand for developing production capacities.
- We need an international production network for renewable electricity and climate-neutral hydrogen to bring electricity-based SAFs into circulation as quickly as possible. One nation alone cannot produce the necessary quantities, especially as other sectors (steel, chemicals, heavy goods transport, shipping) will also convert their operations to hydrogen and synthetic fuels.
- We urgently need to develop a hydrogen infrastructure and a reliable and cost-reducing regulatory framework to ramp up the production of electricity-based synthetic fuels.
- Price-setting legislation can curb price gouging, which generates additional demand and thus also increases greenhouse gas emissions from aviation. The federal government already decided on such an intervention in its 2019 climate protection deal, which has not yet been implemented. The plan foresees that air fares cannot be marketed below the cost of taxes and fees. This rule should swiftly enter into force.



IV. Conclusion

Expanding rail transport

As the railway system improves its services in terms of speed, reliability, and comfort, we are already seeing successful examples of domestic air traffic shifting to rail, most recently, for example, with the complete discontinuation of the Berlin-Nuremberg air route. Today, the critical travel time determining a traveler's choice of transportation is around three hours.

The situation is more complicated for connecting flights to international destinations. Passengers from Germany usually have the option of choosing a connecting flight to another European hub (London, Paris, Istanbul, etc.). Legal restrictions on domestic connection flights would therefore trigger a shift to foreign airlines and airports.

We can successfully shift more traffic to rail when railway providers offer attractive services:

- Rail must become faster to compete successfully with air travel.
- We need better railway service to airports with international connections.
- This also includes the option to check baggage at the station all the way through to the following connecting flight.

Federal and state governments need to provide the necessary investment funds for expanding railways to enable Deutsche Bahn to implement its mission of a consistent, countrywide timetable system called "Deutschlandtakt". Cooperation between airlines and railways should also be intensified.

A successful transition to climate-neutral air travel by the middle of the century will depend on a joint effort by science, industry, airlines, airports, and political actors. Once a dynamic towards climate neutrality is forced into motion, new potentials for ecological innovations will arise. It is crucial to take determined steps. The future starts now.

LIB MOD

Zentrum
Liberale
Moderne

From a global perspective, demand for air traffic will resume and grow after the COVID-19 crisis. The move towards climate-neutral air travel offers great opportunities for Germany and Europe to become pioneers of a future industry — from aircraft construction and propulsion technology to the production of climate-neutral fuels at an industrial scale. We believe that making air travel compatible with climate protection is a realistic goal.

Publisher:

Zentrum Liberale Moderne
Reinhardtstrasse 15
10117 Berlin
Germany

T: +49 (0)30 - 13 89 36 33
M: info@libmod.de

www.libmod.de