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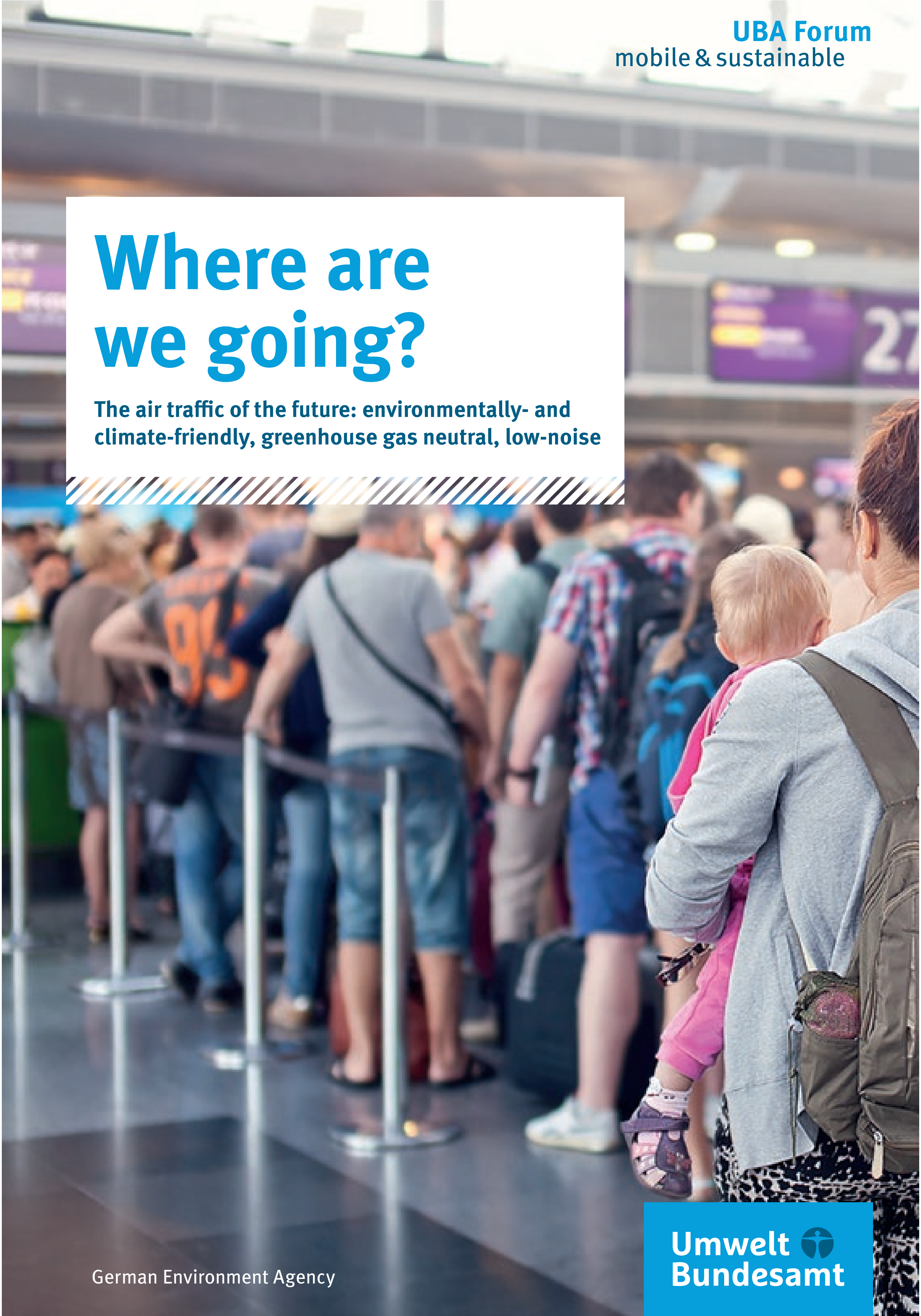

# Where are we going?

## The air traffic of the future: environmentally- and climate-friendly, greenhouse gas neutral, low-noise

German Environment Agency

Umwelt Bundesamt

# Imprint

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# Where are we going?

UBA Forum 2019

# The air traffic of the future

environmentally- and climate friendly
greenhouse gas neutral
low noise

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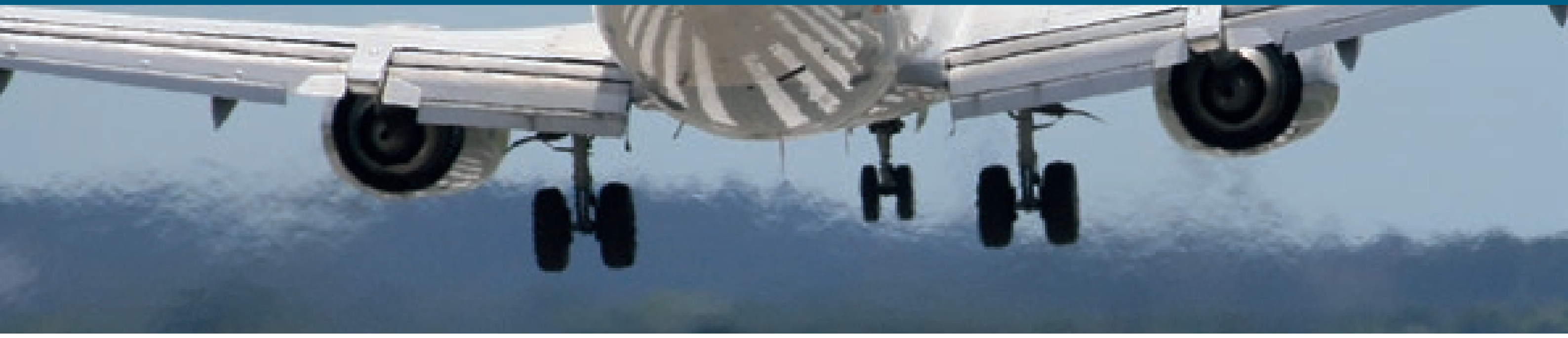
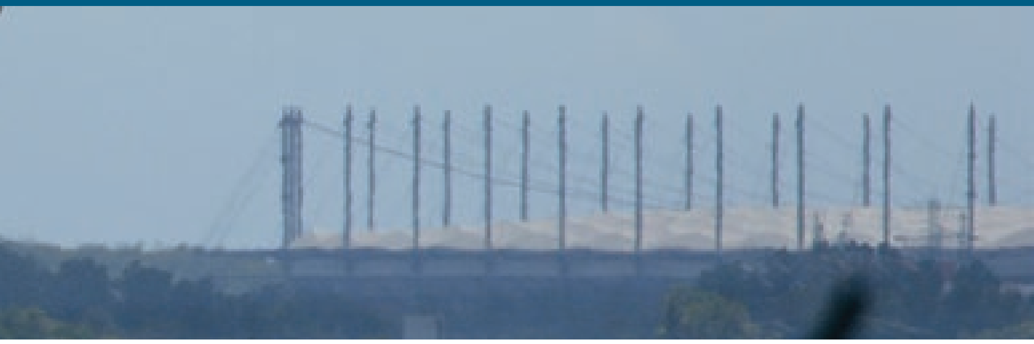




# 1

# Introduction

There are several reasons to fly: flying connects people and cultures, it is an expression of the increasing prosperity around the world, and it allows the exchange of goods, knowledge and values.

There are also reasons against flying, however. The negative side of air traffic includes emissions of air pollutants, carbon dioxide and other greenhouse gases, as well as high levels of noise pollution.

Increasing numbers of people are flying. In 2018 alone, passenger air traffic worldwide increased by 6.7 per cent in comparison with the previous year. And it is continuing to grow. Thus the burdens also grow. The German Environment Agency (UBA) has therefore dedicated this brochure to a subject which is both important and very complex. How much air traffic is really necessary? At what costs to people, the climate and the environment will it be tolerable in the future? How can we achieve an environmentally-friendly transport transition which not only includes aircraft and airports, but also changes to the economy and consumer behaviour?

Air traffic is largely an international matter, which makes internationally-coordinated activities particularly important. Measures and instruments can also be effective at the national or European level, however. A wide range of possibilities for reducing the environmental impact of air traffic already exists. This requires rapid and consistent action by the stakeholders at every level, though.

This brochure is based on a comprehensive UBA study which describes an overall strategy for environmentally-friendly air traffic in the future. The goals, measures and instruments proposed by the UBA in this strategy and which are presented in this brochure focus on commercial scheduled-, chartered- and freight air traffic, because these are the primary cause of the noise pollution, pollution by harmfuls substances and the climate impact of air traffic. They allow for the implementation of a "vision for environmentally-friendly air traffic" in which the UBA determines the environmental and transport policy goals that should be achieved in the short- (2020), medium- (2030) and long-term (2050).

# The air traffic of the future: the skies are becoming congested

# 2

# The air traffic of the future: the skies are becoming congested

Global air traffic has been increasing for decades and sets new records almost every year. In 2018, with some 4.3 billion passengers worldwide, more people flew than ever before – in purely mathematical terms, at present, every second person of the world boards a plane at least once a year. In fact, the use of air traffic is distributed very unevenly: a very small share of the world's population flies a lot whereas most people have never flown before. In Germany, the number of air passengers has tripled over the last 28 years.

## The reasons why:

**Flying is affordable.** Over the last 20 years, the basic transport costs of air traffic have fallen by a half. Low fuel prices and higher rates of fuel efficiency, lower staff costs and aircraft procurement costs, as well as optimised air traffic management have led to ticket prices that many people are able to afford. For years, people have been flying in a "flight-friendly" world, with increasing numbers of airports, more and more connections, a customised hotel and leisure infrastructure and simplified visa requirements making flying into a very attractive means of transport. In terms of demand, it is evident that increasing material prosperity is going hand in hand with more air travel per household, which is clear in the middle classes of Europe, the USA, and to an increasing degree, also in India and China, for example.

**Flying is routine.** A long weekend is the ideal opportunity: why not book a flight to Rome or London? For part of the general public, spontaneous cheap flights have become part of everyday life, and tourism is a key driver behind the rapid increase in passenger volume. A representative survey in Germany showed that people from the "affluent" and "critical/creative" social classes fly particularly frequently. Single people board aeroplanes particularly often. Flying is also the norm in the world of everyday global business. In 2017, some 20.8 million business trips were completed by air. Remarkable: on average, in 2017, one in two business travellers flew eleven times or more. This also means that if air travel were to become more expensive, its negative social impact would be limited, because target groups that are weaker from a socio-economic perspective would invariably fly less frequently.

**Flying enables rapid deliveries, worldwide.** Air freight volumes have also increased hugely – between 1991 and 2017, by about 240 per cent in Germany alone. Without air travel, supply chains and stages in the value added chain that are scattered all over the world would be inconceivable for many goods. Although air freight prices are several times higher than the costs of transporting goods by road, rail or sea, air traffic is profitable for high urgency goods, goods with a short shelf life or goods of particularly high value. Above all else, however, both companies and consumers have become accustomed to products from distant countries being available at any time and without undue delay. In terms of the German economy, 27 per cent of the value of all goods imported and exported to third countries is currently transported by air.

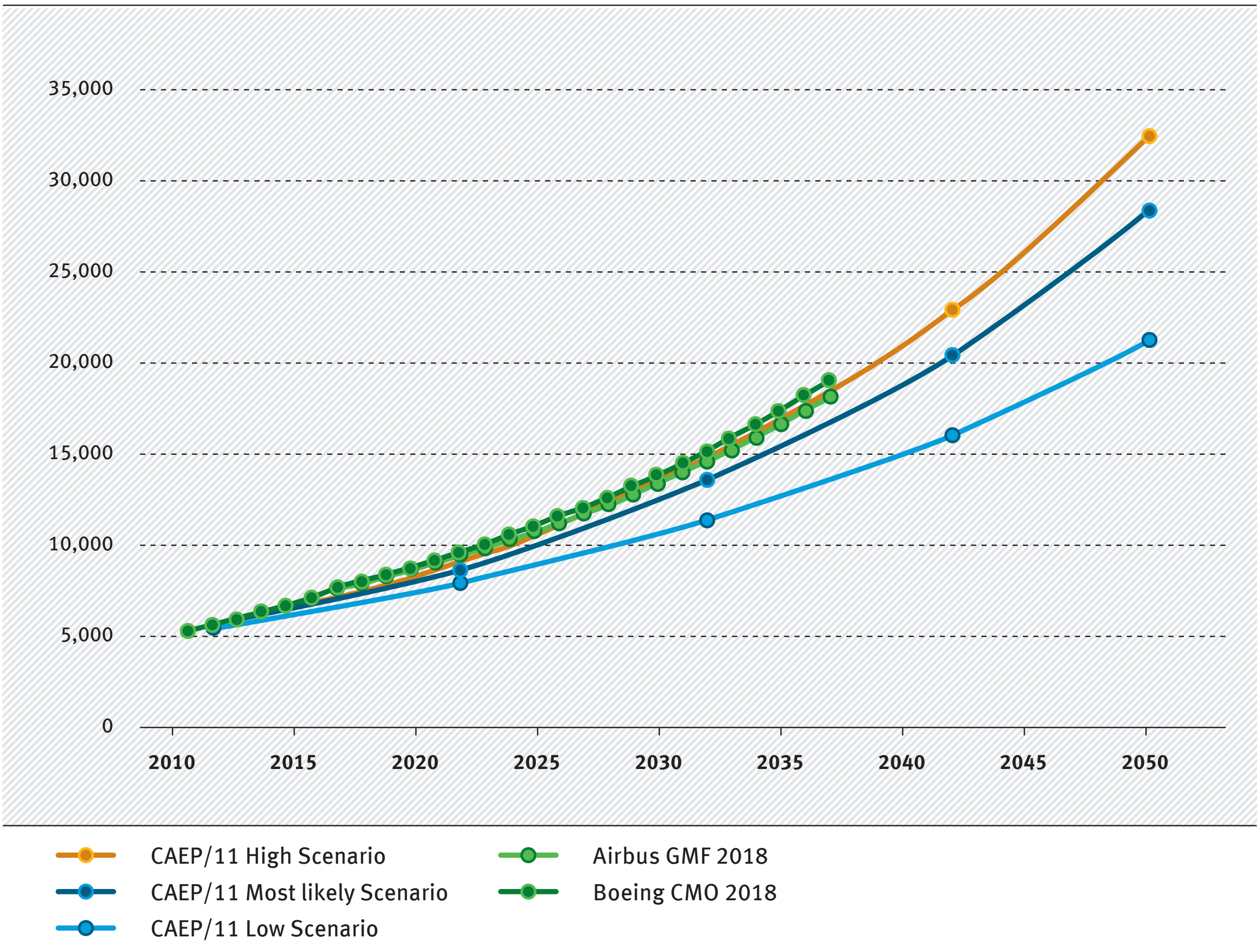
## And in the future?

Air traffic will continue to grow – at least as long as present trends continue. This is something that the aircraft manufacturers Airbus and Boeing, as well as authorities, research institutes and the International Civil Aviation Organisation, the ICAO, agree on. The steepness of the growth curve depends, among others, on the global economic situation. The ICAO – the specialist organisation of the United Nations for International Civil Aviation – has estimated that in an economically prosperous world, the number of passenger kilometres will increase by 4.8 per cent per year, and that even with low economic growth, the annual increase will be 3.6 per cent. The scenario which is considered the most likely by the ICAO (see Figure 01, "most likely scenario") calculated an annual increase of 4.4 per cent, which would see the air traffic volume doubling every 16 years or so.

Figure 01

**Comparison of air traffic forecasts until 2037 respectively 2050**

Transport volume (passenger kilometres in billions)

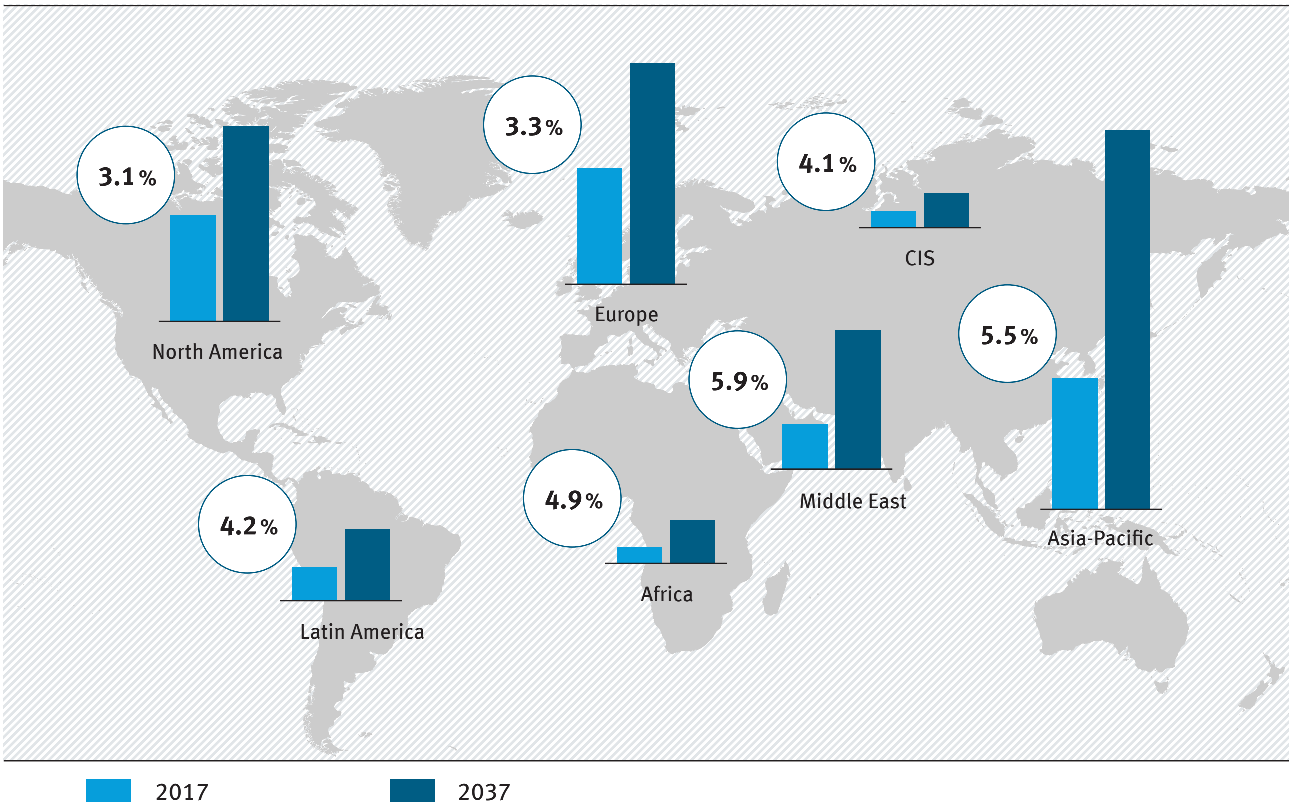



Source: presentation of UBA according to data from (German Öko-Institut, Climate protection in aviation and maritime transport: Aviation strategy paper, 2019)

Also certain: The increase isn't the same everywhere in the world. Relatively high rates of growth in the traffic volume of up to six per cent per year can be expected for Asia and the Middle East (see Figure 02). Meanwhile, the busiest regions (Europe and North America) will grow by a at least three per cent per year.

Figure 02

**Growth in transport volume from 2017 to 2037 in passenger kilometres, differentiated to world region**




Source: presentation of UBA according to data from (Airbus, global networks, global citizens: global market forecast; 2018–2037, 2019)

In Germany, a 3.3 per cent annual increase in passenger numbers is expected by 2030. In figures: while there were approximately 115 million outbound air passengers in 2017, in 2030 there will be roughly 175 million. Domestic air traffic, in contrast, is set to grow at a much slower rate of just under 1.5 per cent by 2030, and will gradually reach saturation point. However, for freight transport, things are different. This is set to increase to 7.3 million tonnes in Germany by 2030, equivalent to more than three times the total for 2014, and corresponding to an annual growth rate of 7.5 per cent.

When more people fly and more cargo is transported, more and bigger aircraft are required. Airbus expects to double the site of the global aircraft fleet by 2036. This growth will lead to more emissions, more noise and a higher consumption of resources, and require the expansion and new construction of the necessary infrastructure worldwide. New, significantly more efficient and quieter aircraft may be able to reduce the levels of emissions and noise. They are only penetrating the market gradually, after all, as an aircraft has an average service life of around 20 years.

In recent decades, commercial air traffic has been completed almost exclusively by kerosene-powered, jet-engine aircraft which can carry between 100 and 500 passengers. In the future, however, electrically-powered engines could also play a role. For aircraft that weigh several tonnes and which cover distances of several thousand kilometres, nonetheless, the requirements of the battery systems are far higher than those for cars, for example. At present, the energy density of the storage batteries only amounts to around a tenth of the output which is required for use in air traffic. The experts therefore expect hybrid aircraft, in which electrical power only provides part of the propulsion energy, will take to the skies first. Consequently, liquid fuels will continue to dominate commercially scheduled and chartered air traffic.

# Unpopular freight: environmental pollution caused by air traffic


3

# Unpopular freight: environmental pollution caused by air traffic

In fact, everyone knows: air traffic damages the environment and climate and worsens the levels of air quality, and can thus have a negative impact on human health. Building aircraft and airports requires land and materials. For many people, the noise caused by aeroplanes is also a considerable problem.

**Energy consumption:** In air traffic, the use of kerosene and the final energy demand are increasing all the time. The increasing number of flights means more efficient aircraft can make little difference. In Germany, the amount of kerosene to be used as air traffic fuel more than doubled between 1990 and 2017, and rose by 73 per cent worldwide in the same period. It is estimated that the world of air traffic will use two to four times as much kerosene in 2050 as it does today.

**Impact on the climate:** Burning kerosene results in carbon dioxide ($CO_2$) as well as smaller quantities of methane and nitrous oxide. These gases alter the radiation balance and cause an additional greenhouse effect – the earth heats up. An aircraft also emits particles, water vapour, sulphur and nitrogen oxides which lead to the formation of contrails and additional cirrus clouds at cruising altitude; they also influence the concentrations of certain atmospheric gases. Some of these non-$CO_2$ effects have a cooling effect, while others have a warming effect. Above all else, however, the climate researchers are convinced that they have a heating effect.

The overall climate impact of all the exhaust gases from an aircraft at cruising altitude is approximately two to three times higher than that of the straightforward $CO_2$ emissions.

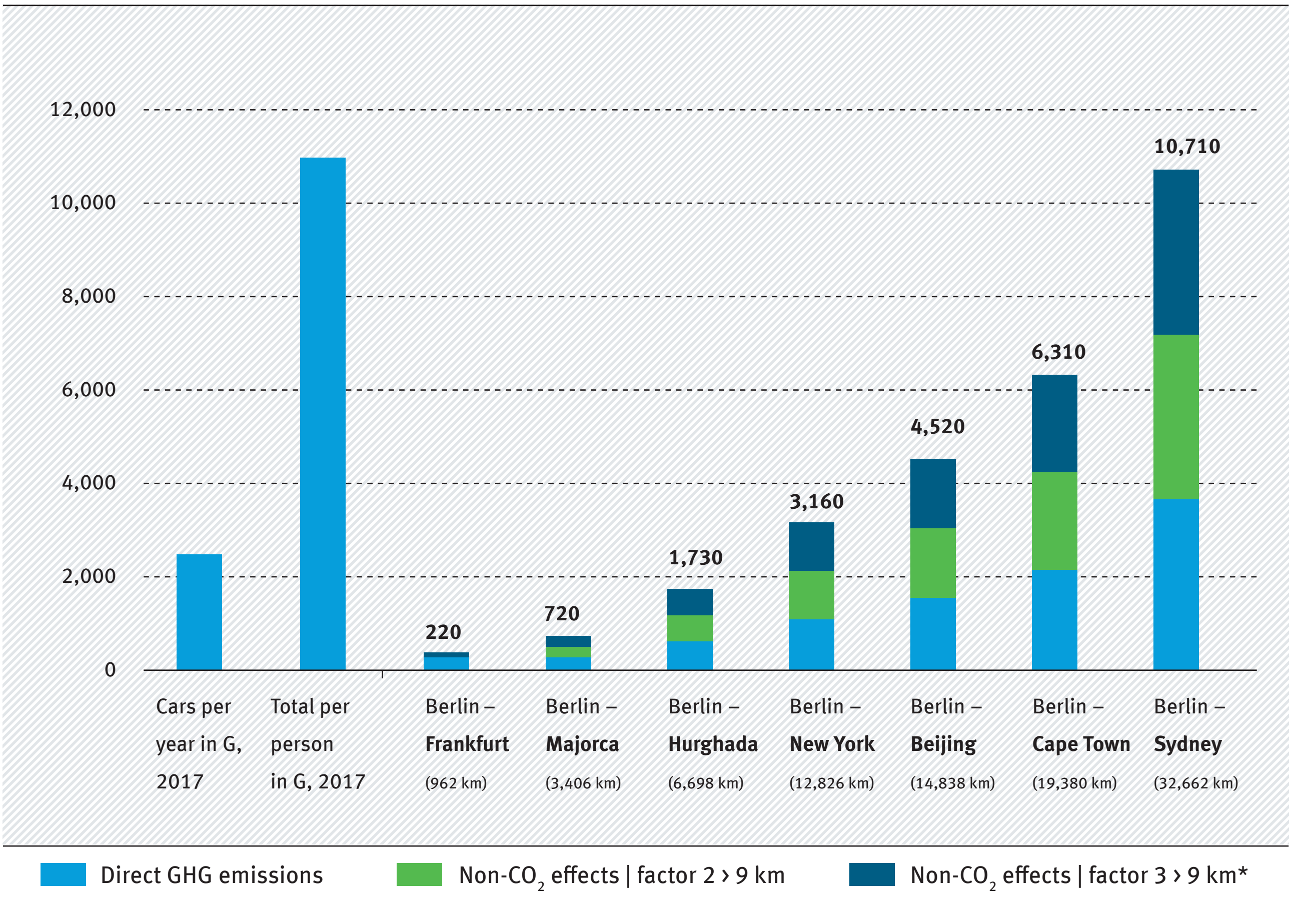
It is indeed the case that air traffic as a whole – compared, for example, with power stations or motor vehicle traffic – currently seems to be responsible for a relatively small proportion of the greenhouse gases attributable to human activity. In this respect, air traffic only accounts for approximately 2.5 per cent of all global $CO_2$ emissions. This figure does not consider the elevated impact on the climate of harmful substances at cruising altitude, though. Taking the non-$CO_2$ effects into account, air traffic currently accounts for five to eight per cent of the global climate impact.

Moreover, this is only a snapshot. According to the relevant forecasts, $CO_2$ emissions from air traffic threaten to increase significantly within the next 20 to 30 years – in Germany, by around 45 per cent by 2050, and globally by at least twice as much. As air traffic increases, so does its impact on the climate and its contribution to climate change. After all: those who fly usually cover greater distances than they would by train or car. This means that even a single long-haul flight can cause more damage to the climate than one whole year of driving a car (see Figure 03).

The effects on the climate are exacerbated by the supersonic aircraft for use in civil air traffic which are currently being developed by several companies. These are expected to emit five to seven times more $CO_2$ per passenger than today's aircraft do. As they are expected to fly at even higher altitudes, and therefore in more sensitive atmospheric layers, they will also intensify the non-$CO_2$ effects.

Figure 03

**Comparative climate impact of outward and return flights per person**
in kg $CO_2$ equivalents




* Difference to factor 2

Source: Calculation of UBA according to atmosfair (2019)

The impact caused by global air traffic presents a major challenge in terms of the climate protection goals of the international community: this aims to limit global warming to well below 2 °C in comparison with the pre-industrial level, for which it is necessary to achieve global greenhouse gas neutrality by 2050. Scientists have determined the size of the $CO_2$ quota which may continue to be emitted globally until then in order to be able to meet these goals. Accordingly, the entire civil air traffic sector will need between 4.3 and 14.8 per cent of this quota by 2050 – depending on how strongly the global economy grows during this period.

To date, the international air traffic industry has only agreed to reduce direct $CO_2$ emissions to half of the 2005 baseline level by 2050. The growth in air traffic from 2020 to 2035 is to be $CO_2$-neutral, above all else, through offsetting with the use of emissions reduction certificates. Even if this succeeds, one problem remains: the climate-damaging non-$CO_2$ effects of air traffic aren't taken into account. Therefore, climate-neutral flying is also impossible in the long term with the existing technology. If it takes its climate protection goals seriously, accordingly, the international community needs to reduce both direct greenhouse gas emissions from air traffic and to drastically reduce the non-$CO_2$ effects at the same time.

**Air pollution:** Flight operations and other activities at airports generate air pollutants such as nitrogen oxides, hydrocarbons and particulate matter. Comparative measurements show, however, that the concentration of these pollutants in and around airports isn't much higher than it is in other areas. Despite this, jet engines also produce ultra-fine particles (UFP) consisting of soot and sulphur-containing particles. As these particles are tiny, current analytical methods are unable to record them adequately. Individual scientific measurements in the USA, the Netherlands and Denmark have shown increased UFP loads in the vicinity of airports. Yet, clear statements on the contribution of air traffic are difficult to make because ultra-fine dusts are also produced by car traffic, industry and heating systems in private households.

From today's perspective, particulate matter and nitrogen dioxide ($NO_2$) are of particular relevance to health. Nitrogen dioxide has a strong oxidative effect, and can cause cell damage in and inflammation of the lung tissue. Fine particulate matter also penetrates deep into the respiratory tract; UFP can also enter the bloodstream and is considered to be responsible for respiratory and cardiovascular diseases. To date, there has been a lack of reliable statements on the long-term health effects of ultra-fine particulate matter in particular. According to the precautionary principle, however, emissions of UFP and their relevant precursors should be reduced.

**Aircraft noise:** Aeroplanes make a lot of noise and very few people would choose to live in the immediate vicinity of an airport. Surveys conducted by UBA show that four out of ten people in Germany are annoyed by aircraft noise. For many people, aircraft are the worst source of noise in the area of transport, and cause more concern than cars or trains at the same noise level. The latest noise mapping according to the EU Environmental Noise Directive from 2017 shows that more than 800,000 people are affected by aircraft noise from the eleven major German airports, including more than 200,000 at night. The majority of those affected live in the vicinity of the airports of Berlin, Frankfurt am Main and Cologne/Bonn (see Table 01).

The number of those adversely affected by aircraft noise is actually higher, as the mapping does not include smaller passenger airports, military airports or airfields. Furthermore, only persons with an exposure of more than 55 dB(A) for a 24-hour day ($L_{DEN}$) and 50 dB(A) for the night ($L_{Night}$) are shown here.

Tab. 01

**Persons affected by aircraft noise at major airports in Germany in 2017 according to the EU Environmental Noise Directive**

| Federal state | Major airport | $L_{DEN}$ > 55 dB(A) | $L_{DEN}$ > 60 dB(A) | $L_{DEN}$ > 65 dB(A) | $L_{DEN}$ > 70 dB(A) | $L_{Night}$ > 50 dB(A) | $L_{Night}$ > 55 dB(A) | $L_{Night}$ > 60 dB(A) |
|---|---|---|---|---|---|---|---|---|
| Brandenburg/Berlin | Berlin-Schönefeld | 34,600 | 12,100 | 400 | 0 | 14,000 | 600 | 0 |
| Berlin | Berlin-Tegel | 278,800 | 133,900 | 25,300 | 2,500 | 90,200 | 16,200 | 1,000 |
| Baden-Württemberg | Stuttgart | 35,500 | 4,500 | 0 | 0 | 1.700 | 0 | 0 |
| Bavaria | Munich | 13,700 | 2,900 | 200 | 0 | 3,600 | 200 | 0 |
| Bavaria | Nuremberg | 12,100 | 1,900 | 100 | 0 | 4,300 | 200 | 0 |
| Hesse | Frankfurt am Main | 189,300 | 18,400 | 0 | 0 | 36,700 | 300 | 0 |
| Hamburg | Hamburg | 63,400 | 17,600 | 4,100 | 200 | 9,900 | 1,800 | 200 |
| Lower Saxony | Hanover | 19,500 | 4,700 | 200 | 0 | 9,200 | 1,600 | 0 |
| North Rhine Westphalia | Düsseldorf | 56,700 | 19,600 | 3,400 | 1.000 | 9,800 | 2,600 | 0 |
| North Rhine Westphalia | Cologne/Bonn | 101,400 | 17,700 | 600 | 0 | 53,000 | 10,600 | 300 |
| Saxony | Leipzig/Halle | 10,500 | 2,600 | 0 | 0 | 8,100 | 2,100 | 0 |
| **Sum total** | | **815,500** | **235,900** | **34,300** | **3,700** | **240,500** | **36,200** | **1,500** |

Source: German Environment Agency (2018)

The number of people adversely affected by aircraft noise has increased since 2012, with more and more large jets taking to the skies and increasing numbers of flights at night. Forecasts predict that until 2040, the noise pollution from the 47 biggest airports in Europe will roughly remain the same. Although the proportion of quieter aircraft is set to increase in the future, this advantage will largely be compensated by the increase of aircraft movements.

Too much aircraft noise can make people ill. It reduces the quality of life and sleep, and can affect the blood pressure, heart rate, hormone balance and metabolism. The World Health Organisation therefore recommends that an $L_{DEN}$ value of 45 dB(A) and an $L_{Night}$ value 40 dB(A) should be complied with in order to protect the general public from the effects of aircraft noise on human health. The UBA supports these recommendations.

**Use of land:** Airports need space – for runways, aprons, hangars, air traffic control systems, not to mention the administration buildings, passenger terminals and air freight terminals. These are joined by the access roads, car parks, hotels, restaurants and businesses. Nowadays, a modern airport often resembles a small town with an airfield. The runways account for a small part of the total land consumption.

Figure 04

**Aerial photo of Frankfurt am Main airport**

Highlighting of the airport border

Limits of the airport

Source: presentation of UBA on the basis of basic-DLM (AAA) and DOP20 © GeoBasis-DE/BKG (2019)

For the 25 German major airports with at least 200,000 passengers a year, the total area of all the airport facilities is approximately 140 km². Just 4 per cent of these are runways. On average, 40 per cent of the facilities are sealed off. Another 13 regional airports account for a further 40 km². Taken together, all of the major and regional airports in Germany are around the same size as the city of Potsdam. Also surprising: A further approx. 190 km² – and therefore more than the total area of all commercial and regional airports – is accounted for by approx. 950 small airfields , which are only partially used for commercial air traffic, and otherwise for sports or private purposes and/or for rescue services. At smaller airfields, the area efficiency, meaning the passenger and freight volume per hectare, is exceptionally unfavourable.

**Water and soil:** To ensure safe flight operations, both aircraft and operational areas have to be de-iced in the winter. This results in waste water which is contaminated with hydrocarbons as well as salts and harmful substances. Consequently, the waste water has to be collected and treated separately, which is ensured at German airports. The use of extinguishing foams which contain fluorine for fires involving liquids and melting solids is problematic. The fluoro-chemicals that such foams contain (perfluorinated and polyfluorinated chemicals – PFC) are so chemically stable that they fail to break down into harmless substances in either the soil or at waste water treatment plants. The PFCs used in the current extinguishing foams are very mobile, i.e. they are only retained in the soil to a limited degree, and thus find their way rapidly into the groundwater. The extinguishing water must therefore be collected, cleaned and disposed of properly. As regards these short-chain PFCs, no effective or efficient methods are available for the remediation of the contaminated soil or groundwater. Due to environmental concerns, some airports have already switched to fluorine-free extinguishing foams, including international airports such as London Heathrow.

# Plenty of room for improvement: the vision for environmentally-friendly air traffic

# 4

# Plenty of room for improvement: the vision for environmentally-friendly air traffic

Global air traffic is currently heading in the wrong direction. Its enormous growth is a threat to the global climate protection goals, it endangers human health through noise and air pollutants, consumes finite resources and is anything but sustainable. In consequence, the UBA advises a significant change of course.

What does a better air traffic look like then? Which goals must be achieved and by when? And by what means? For this purpose, the UBA has developed a **vision for environmentally-friendly air traffic.** This sets out the environmental and transport policy objectives that are to be achieved in both the medium term (2030) and the long term (2050).

The **eight modules of** the vision are based on a variety of instruments and measures at the national, European and international levels. Some modules are simpler, while others are more difficult to realise. Restricting the measures to individual areas isn't advisable, however, as other environmental problems surrounding air traffic would then remain unresolved. Many of the goals are interlinked with each other – something which also speaks against the realisation of individual modules only.

A vision always looks to the future and should have ambitious goals. This also applies to the vision of the UBA for environmentally-friendly air traffic. The vision isn't a utopia, though, because the goals and scenarios are achievable: with the right economic framework conditions, with ambitious targets and ambitious packages of measures that are effectively coordinated.

If the eight modules become a reality, in the year 2050, air traffic can be compatible with people and the environment. Aircraft will then be much quieter, low on emissions and more efficient – and with a completely new, environmentally-friendly fuel. Non-$CO_2$ effects at high altitudes will be reduced to a minimum. Short-haul flights will become superfluous. The volume of flights will be developing in line with its environmental compatibility.

*Modul 1:*
## Configuring sustainable infrastructure

According to the vision of the UBA, the federal government is making consistent use of its managerial options to achieve an environmentally-compatible air traffic infrastructure in Germany. In this respect, airports will only be expanded if the plans are in line with the GGermany-wide site planning and meet the environmental policy objectives – this applies to airports with night flight operations in particular. No further passenger airports will be built in Germany. Locations for which no demand has been identified according to this planning will be closed by 2050, and the areas that are freed up will be restored to their natural state or classified for alternative use.

Those who operate or use airports have to pay the costs – subsidies are no longer allowed. By 2050, appropriately adapted polluter-pays-based taxes and fees will help to steer the volume of air traffic and use the existing infrastructure so that the levels of environmental pollution around airports are reduced as far as possible. The Germany-wide airport site planning is also working towards ensuring that only air traffic which is absolutely necessary takes place at airports which are already busy and located close to residential areas.

*Modul 2:*
## Moving short-haul flights to rail

On routes on which the train is as fast as the plane (including arrival/departure, check-in/check-out), no scheduled flights will take place by 2030. After all, the consistent expansion of the rail network and a significantly improved range of services will have made the railways into an attractive alternative.

This applies, in particular, to connections between the major conurbations which are accessible by rail within about four hours. The transfer of short-haul flights to rail will free up capacity at the airports. The close links of the major German airports to the intercity transport network will replace feeder flights. A change in the tax framework for air and rail transport will also make rail travel more attractive.

By 2050, Germany will have a good rail transport service with a high level of service quality which is able to replace almost all of the scheduled flights between the German passenger airports and conurbations. This also applies to many shorter international flights. In the case of longer flights, combining rail travel and flights in the form of a single ticket eliminates the need to travel by car. Freight traffic also benefits from an efficient rail system: by 2050, fast goods trains, which also travel at night, will replace domestic freight flights.

*Modul 3:*
## Minimize climate-relevant emissions

Germany and Europe will introduce instruments to reduce $CO_2$ emissions from air traffic to their 2010 levels by 2030. At the same time, the international community will agree to a global climate protection mechanism which will reduce $CO_2$ emissions from air traffic worldwide.

Simultaneously, the switch to synthetic fuels produced from renewable electricity (Power to Liquid, PtL) will begin. As a first step, demonstration plants will be built worldwide at locations in which enough renewable electricity is available at affordable prices. By 2030, considerable investments in plant and equipment by leading economies such as Germany will enable PtL to be produced on a large scale and at marketable prices by 2030. Individual airlines will start to introduce PtL on a large scale and gradually replace the fossil fuel of kerosene. Regulatory measures at the national level, and later at the European level, such as a binding compulsory blending quota, will accelerate the market launch of PtL.

As climate-impacting emissions, from water vapour, for instance, cannot be completely avoided, even with the use of PtL, the non-$CO_2$ effects of air traffic must also be reduced. By 2030, the climate effects of non-$CO_2$ emissions from aircraft will have been researched in greater detail and be quantifiable for individual flights so that flight routes can be optimised according to their climate impact. The integration of non-$CO_2$ effects into an efficient global climate protection mechanism begins. If global regulations for this cannot be implemented or cannot be implemented quickly enough, the leading European nations will start to incorporate the non-$CO_2$ effects into their emissions trading.

By 2050, in addition to Germany and the EU, other major economic regions such as the USA, Japan and China will also have achieved $CO_2$-neutral air traffic. Direct greenhouse gas emissions from the fossil fuel of kerosene will be reduced to zero by 2050, among others, by using PtL fuels all over the world. The aircraft of the future will be so efficient that by 2050 they will require approximately 55 per cent less fuel per person-kilometre and tonne-kilometre than in 2010. Over this period, the efficiency of the aircraft fleet will increase by roughly two per cent per year.

To reduce the non-$CO_2$ effects to a minimum, in addition to the climate-friendly routing of each flight, these will be integrated in the air traffic climate protection mechanism. The non-$CO_2$ effects will be significantly lower by 2050 in comparison with 2010.

*Modul 4:*

## Reducing noise – protecting the general public

Serious health hazards caused by aircraft noise will be prevented, as by 2030. On the basis of noise quotas, all airports in Germany will limit the average noise levels in residential areas to 63 dB(A) during the daytime.

By 2050, all airports close to towns and cities will cease regular flight operations between 10 pm and 6 am. Unavoidable night flights will take off and land at a limited number of airports in sparsely populated areas, so that average noise levels in urban residential areas to a maximum of 40 dB(A) are complied with during the night. In addition, noise abatement measures will be vigorously pursued and noise quotas tightened, reducing aircraft noise pollution in residential areas to an average level of 58 dB(A) during the daytime.

These requirements can be met by airports far away from residential areas through strict emission requirements and innovative flight procedures. Airports close to towns and cities will be able to achieve their noise protection goals on the basis of limited flight operations: some of the connections will be relocated to airports far from residential areas with an efficient rail connection.

*Modul 5:*

## Charging environmental costs to the polluter

In the future, the considerable economic environmental and health costs caused by global air traffic will be borne by those who cause them. The full costs of climate change will be charged to the polluter in Europe by 2030, and worldwide, by 2050. The same applies to healthcare costs caused by noise and air pollution. In Germany, these costs will be largely attributed to the polluter by 2030, and fully, by 2050. Subsidies for the air traffic industry which are harmful to the climate and the environment will go – in particular, this applies to the exemption of kerosene from the energy tax, which will be phased out by 2030. The internalisation of external costs will lead to a greater transparency of costs, reduce the demand for flights, and improve the competitiveness of alternative modes of transport. The additional revenues generated will be used to boost innovative environmental and climate protection technology in the field of air traffic.

*Modul 6:*
## Ensuring clean air on location

By the year 2030, extensive knowledge about sources of emissions (in particular, nitrogen oxides, particles and their relevant precursors), and continuous data on concentrations of ultra-fine particulate matter in the vicinity of German airports will be available. By then, clarification will also have been provided on how these emissions can be reduced, and how the legal threshold values on emissions can be safely complied with and/or undercut on.

Aircraft will only burn fuel during take-off, flight and landing operations. This will be made possible by the consistent electrification of apron traffic and by supplying parked aircraft with ground power and fresh air via the passenger boarding bridge. By 2050, the remaining $NO_x$ emissions during each take-off and landing operation will be reduced by 90 per cent compared with the year 2000. Comparable reductions will also be achieved for particle emissions and other precursor substances of the particle formation.

*Modul 8:*
## Fewer flights

The increasing environmental and health problems caused by air traffic are gaining an increasing amount of coverage in the political, social and academic debate. By 2030, many people in Germany and Europe will gradually change their way of thinking. Businesses and consumers will reflect on their chosen mode of transport more strongly than before. Due to economic incentives, regulatory measures and new alternatives in the area of rail transport, they will choose to fly less frequently.

By 2050, this trend will also prevail worldwide. In the best case scenario, that means: the avoidance of holiday flights, the replacement of business flights with high-performance communications infrastructure and the increased demand for products which are grown or produced regionally will reduce the volume of air traffic by 2050.

*Modul 7:*
## Conserving resources, making efficient use of raw materials

By 2030, new aircraft will be designed and materials chosen to ensure that they are as light as possible. Selectively chosen materials will make it possible for aircraft which have reached the end of their useful lives to be largely recyclable by 2050. During the manufacturing of aircraft, energy from renewable sources will be used only. The efficient use of resources also includes the economical and responsible handling of the land and soil during the expansion and conversion of airports, including measures for the reuse of abandoned airfields and/or returning them to nature.

Figure 05

**Vision of the German Environment Agency for environmentally-friendly air traffic by 2030/2050**

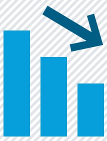
**Modul 1: Configuring sustainable infrastructure**
The federal government will manage the development of the air traffic infrastructure with a requirements planning which is ecologically-oriented and based on an analysis of the expected demand. User-based financing has been introduced.

**Modul 2: Moving short-haul flights to rail**
The expansion of the rail infrastructure, including high-speed railway lines, will allow almost all domestic freight and passenger flights to be shifted to rail.

**Modul 3: Reducing climate-relevant emissions to the minimum**
Climate-relevant emissions from air traffic, including non-$CO_2$ effects, will be integrated into international climate protection mechanisms on the basis of a $CO_2$ pricing system. Renewable PtL will be introduced as a greenhouse gas-neutral fuel worldwide by 2050. Greenhouse gas-neutral flying will be reality in 2050.

**Modul 4: Reducing noise – protecting the general public**
By 2050, noise quotas will be introduced at major German airports which will limit aircraft noise exposure in residential areas during the daytime to an average level of 58 dB(A). At airports close to towns and cities, no regular flights will take place between 10 pm and 6 am by 2050 at the latest.


**Modul 5: Charging environmental costs to the polluter**
The environmental and health costs of air traffic will be charged to the polluter according to their origin (the internalisation of external costs). Environmentally harmful tax concessions will be phased out.



**Modul 6: Ensuring clean air on location**
By 2050, the specific emissions of nitrogen oxides ($NO_x$), particulate matter and precursor substances during take-off and landing operations will be reduced by 90 % in comparison with 2000 through new engine technology. Apron traffic will become emissions-free through electrification.

**Modul 7: Conserving resources, making efficient use of raw materials**
The production of aircraft will take place on a fully recyclable and renewable basis by 2050. The use of land will be minimised through the economical and responsible use of land and soil in the development of airport infrastructure, and with measures for the reuse of abandoned airfields or for returning them to nature.

**Modul 8: Fewer flights**
Where technical innovations and measures fail to bring about the necessary reductions in climate effects, noise emissions or emissions of air pollutants, the development of the air traffic volume will be linked to its environmental compatibility through regulatory instruments and economic incentives.

Source: German Environment Agency (2019)

# What we can do: instruments and measure


5

# What we can do: instruments and measures

One thing is certainly clear: if the vision of the German Environment Agency for low-noise, environmentally-friendly and climate-friendly air traffic is to become a reality, it will be a major challenge for all of the stakeholders involved. There is no patent recipe and there are no simple solutions. Only a package of measures and instruments, some of which will have to be anchored locally or nationally, some of which are European, others of which are international, can promise success.

The goal of all measures and instruments is ideally to make air traffic greenhouse gas neutral, to significantly reduce the noise levels, and to internalise the environmental costs borne by society to ensure a greater equity of costs and create effective environmental economic incentives. The recommendations and proposals for action will not throw the existing system of air traffic out of kilter. Rather, most of them are already the law or at least known, tested at a rudimentary level, or in development.

Time is crucial. Rapid action is needed to mitigate the negative impact of air traffic on both people and the environment.

When it comes to global challenges, especially climate protection, global instruments naturally promise greater impact than national or European solutions. Global agreements and regulations take a long time, however. Where a major solution is not in sight, it will be necessary for individual stakeholders such as Germany or the European Union to take the first steps.

### The right framework: economic and spatial planning instruments

Air traffic is subject to several national, European and international agreements, laws and regulations. This will not be any different in the future. The right framework conditions are therefore of considerable importance in achieving environmentally-friendly air traffic.

Those who are pleased about their cheap flight for their next holiday, should also be aware that the favourable price is also a consequence of subsidies. For example, international, commercial air traffic in Europe is exempt from value added tax (VAT). For German air traffic alone, these subsidies amount to some 4.2 billion Euros per year. The fuel is also subsidised. Kerosene is not subject to an energy tax. If the amount of kerosene used as fuel in Germany were priced with an energy tax in the same way as petrol (65.45 cents per litre), the annual tax revenues would amount to approximately 8.1 billion Euros.

These exemptions from VAT and energy tax in Germany result in competitive disadvantages for other modes of transport, such as rail. A corresponding reduction in the subsidies for air traffic would thus have a considerable ecological incentive and ensure greater tax justice.

A price must be set for the greenhouse gas emissions from air traffic. Economic instruments influence the cost of kerosene and flight tickets and the cost of air freight as well as the take-off and landing fees.

Their advantage: they enable environmental protection goals to be achieved at lower economic costs than regulatory measures and instruments, for example. The polluter decides for himself/herself which approach they personally find more economical: reducing the environmentally harmful pollution, or paying a price for such pollution. The strengths of economic instruments are to be found where the overall toxic load is of decisive importance, with the protection of the climate, for instance. They can also reduce pollution at the local level, an example being noise- and pollutant-dependent take-off and landing fees at airports.

Price policy measures are essential for achieving environmentally and climate-friendly air traffic, but they are not sufficient on their own. Planning also helps to steer air traffic in an environmentally-friendly direction. Spatial planning instruments determine the spatial distribution of the airport capacities, the connection of the airports to the railway network and the distribution of the noise pollution, and therefore the numbers of people affected by noise.

Germany, the EU, and also the international community must do more than ever before to promote economic and spatial planning instruments in the interests of creating a stable framework for environmentally-friendly and climate-friendly air traffic. In this respect, the UBA proposes five specific courses of action.

**Reform of the Air Traffic Tax:** The Air Traffic Tax was introduced in Germany in 2011. Since the start of 2019, 7.38 Euros per passenger have been payable for short-haul flights, 23.05 Euros for medium-haul flights including domestic feeder flights, and 41.49 Euros for long-haul flights. For the vast majority of passengers, these fees are pretty modest. The tax on short-haul flights, low as it is, doesn't just apply to short geographical distances, but covers almost the entire Mediterranean region. The fee for medium-haul flights extends to the Arabian peninsula.

The Air Traffic Tax is capped at 1 billion Euros per year and linked to the European emissions trading: when the revenues from the certificates trading increase, the tax rates fall accordingly.

A step towards achieving greater environmental protection in air traffic and greater tax equity between the modes of transport would be to lift the cap and to decouple the ticket tax from the emissions trading. Reforming the Air Traffic Tax is also an opportunity to increase the surcharges to an environmentally effective level.

In specific terms, the UBA recommends at least doubling the Air Traffic Tax in the short term and increasing it by 2030 such that the tax shortfalls are offset by the VAT exemption on international flights. At the same time, the reform could also adapt the distance categories and make them more appropriate to the polluter. If the ticket tax were also staggered according to how much noise and emissions the specific aircraft cause, cleaner and quieter aircraft would become much more economical.

**Introduction of a Kerosene Tax:** From the point of view of the UBA, an EU-wide Kerosene Tax would be another key step towards the equal treatment of different modes of transport and, in addition to the emissions trading, a second contributing factor for a greater degree of climate and environmental protection in the area of air traffic. The 2003 EU Energy Tax Directive allows for taxation on domestic flights and between Member States that agree to them on a bilateral basis. Some EU Member States are resisting new taxes on flights, however. As a first step, the UBA therefore recommends such a tax at the national level in the near future: the introduction of the EU Minimum Energy Tax Rate of 33 cents per litre for domestic flights. Germany should also conclude bilateral agreements with other Member States, and consequently introduce a Kerosene Tax on a small-scale basis. Bilateral agreements can form the core of a future EU-wide solution which should be in place by 2030.

**Air Traffic Innovation and Demonstration Fund:** The increase in the Air Traffic Tax and the introduction of the Kerosene Tax have not yet created $CO_2$ pricing in the field of air traffic, but they do promote an equal tax treatment of the various modes of transport. But how should with the additional tax revenue generated by air traffic be spent? It is naturally the case that proportionate investments will be made in targeted measures for more environmentally-friendly flying! According to the proposal of the UBA, this could lead to a new "Air Traffic Innovation and Demonstration Fund", which would support investments in modern aircraft fleets, quieter aircraft, improved flight routes, sufficiency measures and the market launch of alternative, post-fossil fuels such as sustainable Power to Liquid (PtL). The choice of the right projects should be based on achievable emission reductions, the degree of innovation, transferability and potential cost reductions.

**Further development of emissions trading:** Since 2012, the air traffic industry has been incorporated effectively in the European Emissions Trading Scheme (EU-ETS). The idea behind it: every airline that operates flights between European airports is required to submit permits for $CO_2$ emissions. The level of total emissions is capped by the EU, and the cap decreases a little each year. If the allowances initially allocated by the states are insufficient, the airline is required to buy $CO_2$ certificates ("pollution allowances") on the market. The goal is that all obligated companies will be interested in buying as few certificates as possible, and will actively reduce their emissions.

This approach is yet to have borne much fruit, however. The emissions from air traffic have continued to rise despite the emissions trading system. This is partly due to the framework conditions of the EU-ETS, which has not been sufficiently demanding of air traffic. Within the EU-ETS, airlines do not necessarily have to reduce their own emissions, but can buy the pollution allowances they require from other industries (e. g. industrial plants or power plants). In addition to this, the airlines currently receive approximately half of the certificates they require free of charge. Due to the oversupply of certificates, the price of a certificate was a modest five to ten Euros per tonne of $CO_2$ for many years, although it has now risen to over 25 Euros.

The framework for the EU-ETS is to be revised in the near future. According to the UBA, the requirements must be tightened significantly. A gradual restriction of the ability of airlines to buy certificates from other sectors would be particularly effective. A faster lowering of the emissions cap, the expansion of the auctions and the incorporation of non-$CO_2$ effects into the emissions trading would also strengthen the emissions trading as an instrument. If the EU-ETS is not tightened up by 2030, the UBA considers the introduction of a $CO_2$ component in the Kerosene Tax to be an alternative. The fossil fuel of kerosene would then be subject to a higher rate of tax than fuel produced using renewable electricity (PtL), for example.

The ICAO aims to achieve $CO_2$-neutral growth in international air traffic starting from 2020. The new "Carbon Offsetting and Reduction Scheme for International Aviation" (CORSIA) has been designed to offset $CO_2$ emissions through the purchasing of credits from climate protection projects and certificates from existing emissions trading systems. In addition, aircraft are to become more efficient, flight routes are to be optimised and alternative fuels gradually introduced (which the ICAO understands to mean both synthetically produced fuels as well as biofuels and "better" conventional fuels).

According to the current plans, the CORSIA covers roughly two thirds of the total emissions from global civil air traffic. Flights to less developed countries are not included. Participation is voluntary for states until 2026, from 2027, mandatory criteria should apply to all. From the point of view of the UBA, CORSIA is an opportunity for more climate protection at the global level, although in its current form, the system is not fast enough or ambitious enough to meet the international climate targets. Still, in the long term the UBA sees the further development of CORSIA into a global emissions trading system as a great opportunity to price the $CO_2$ emissions from air traffic on a global basis and to thereby reduce them.

**Airport planning by the federal government:** The construction of new airports or the expansion of existing airports affects several planning authorities and levels at federal and state level, and is consequently highly complex and drawn out. The competencies are determined by law. For example, the federal state examines various locations for an airport and grants the approval for its construction. The Federal Supervisory Authority for Air Navigation Services, on the other hand, determines, among others, the flight routes to be taken by the aircraft. However, there is no superordinated airport planning by the German government, in playing a coordinating role for the activities and interests of the federal states and setting the priorities from an general perspective.

So far, environmental protection factors (especially noise protection) have been considered for the individual airport locations, but the full potential is far from having been exhausted. The UBA therefore recommends that the German government draws up an superordinated airport concept which is agreed between all the federal ministries concerned and optimised in terms of environmental protection factors, and defines a clear function for the airports which are important from the federal perspective. A concept of this kind would be based on a form of requirements planning by the federal government which takes social, economic and above all else, ecological criteria into account. In the requirements planning, the site-specific functions are to be examined on the basis of the (environmental) policy objectives and the previously defined criteria, e. g. whether freight airports with night flight operations will still be necessary in the future. Expansions of specific airports would be linked to the identified requirements. For example, the decision could be taken not to expand an airport any further, because international cooperation or moving goods to the railways would create a situation in which far less air traffic is necessary at that airport.

This would ultimately lead to a German airport network which relies on fewer airports and which also have differing core functions. The Federal Transport Infrastructure Plan would also ensure that all the commercial airports in Germany are connected to the intercity rail network. Above all else, this Germany-wide strategy would ensure that each airport plays its specific role in the overall system, regardless of the planning of the federal states.

The determination of flight routes can and must also be optimised. It is important, for example, that all possible flight corridors are examined for their environmental impact during the planning process.

The general public must also be informed about and included in the decisions concerning the future airport infrastructure and flight routes. For such participation to be possible for as many people as possible, it is essential for the participation to take place in good time, that the process is clear, and that the relevant documents are understandable.

Tab. 02

**Overview of economic and spatial planning instruments and measures**

| Measures and instruments | Latest date of impact | Who decides? | Who is responsible for the implementation? |
|---|---|---|---|
| Increase in the Air Traffic Tax to € 2 billion p. a., decoupling from the emissions trading, inclusion of freight flights, higher weighting of the tariff for short-haul flights | 2020 | Federal government | Airlines |
| Increase in the Air Traffic Tax to the level of the loss in VAT (€ 4.2 billion p. a.), differentiation/incentives regarding noise and emissions | 2030 | Federal government | Airlines |
| Levying of the EU Minimum Energy Tax Rate on kerosene of 33 cents/l for domestic flights | 2020 | Federal government | Airlines |
| Bilateral agreements with EU Member States to levy the EU Minimum Energy Tax Rate on kerosene of 33 cents/l, EU-wide solution in the medium term | 2030 | Federal government + EU Member States | Airlines |
| Creation of an Air Traffic Innovation and Demonstration Fund, for the market launch of sustainable PtL in particular | 2020 | Federal government | Federal government |
| Tightening of the emissions trading system, in particular, the lowering of the cap, restrictions on use with purchases of certificates from the fixed location area, taking the non-$CO_2$ effects into account | 2030 | EU | Airlines |
| Tightening of CORSIA, in particular, an ambitious reduction path, offsetting of PtL | 2030 | ICAO | Airlines |
| Preparation of an air traffic infrastructure concept concerning the national airports, optimized in terms of environmental aspects | 2030 | Federal government | Federal government, federal states |
| Implementation of the airport location concept at all of the affected airports | 2050 | Federal government, federal states | Federal government, federal states |
| Improving the determination of flight routes, in particular, regular environmental impact assessments and participation by the general public | 2030 | Federal government | Federal Supervisory Authority for Air Navigation Services |

Source: German Environment Agency (2019)

## The fuel switch: from the fossil fuel of kerosene to Power-to-Liquid

To make air travel climate- and environmentally friendly, sooner or later it will be necessary for the fossil fuel of kerosene to be replaced. This will be no easy task. Jet engines are designed for a specific mixture of liquid hydrocarbons with a defined and sufficiently high energy density. Therefore, the range of non-fossil alternatives which can be burned in current jet engines is not especially extensive. Biofuels or synthetically produced hydrocarbons, which have similar properties to kerosene, come into consideration. The following applies to all of the alternatives: to offer an advantage for the environment and climate, it must be possible to make them on a greenhouse-gas-neutral basis. It is also necessary for them not to have any other negative ecological consequences.

Biofuels produced from arable crops are eliminated, as they present problems in terms of the sustainability of their raw materials. An expansion of arable land for fuels would lead to more intensive rates of cultivation as well as an increase in the amount of land used for agricultural purpose. Both of these are linked to increased greenhouse gas emissions, which means that these biofuels are not greenhouse neutral. In addition to this, the use of cultivated biomass as a fuel competes with other, higher-value uses: biomass can replace fossil raw materials during the manufacturing of various different products, for example.

Fuels made from waste or residual materials do not have these disadvantages. However, the available quantity of these biofuels is limited from both the domestic and global perspectives. Therefore, these could cover only a small part of the energy requirements of air traffic. Here, too, competition with other uses exists: if this biomass were actually used to generate energy, this would be far more efficient in the industrial or energy sector, for example, and would consequently be associated with higher greenhouse gas reductions in the transformation path.

**Launch strategy for Power-to-Liquid:** All hopes thus lie in synthetic fuels, which are referred to as Power to Liquid kerosene (PtL kerosene) or E-kerosene. The production of PtL is costly, though: firstly, hydrogen is separated from water with the use of electricity.

In chemical plants, the hydrogen reacts with a carbon compound (carbon monoxide or carbon dioxide), which can originate from the air, industrial processes, exhaust gases or biomass. These syntheses result in the production of different hydrocarbons, which are fractionated into the required fuel in a refinery. This produces a liquid mixture which is very similar to fossil kerosene.

In this respect, the following is essential: the electricity required for the hydrogen electrolysis must originate from renewable sources. It is also important that binding sustainability standards are developed for the whole of the value chain. This also includes the fact that the carbon to be used does not lead to increased emissions, but is extracted from the air, for example. The PtL to be produced is only a greenhouse gas neutral fuel if renewable electricity and a greenhouse gas neutral source of carbon are used.

Research into the manufacturing processes for PtL is under way worldwide, although only a limited number of testing and pilot plants actually exist. Although the initial large-scale plants are being planned, sufficient quantities of synthetic kerosene will only be available in the long term. To demonstrate the feasibility of the processes, the UBA is therefore in favour of the rapid construction of demonstration plants at worldwide locations in which sufficient renewable electricity is available at a low cost. Revenues from the Air Traffic Innovation and Demonstration Fund are to be used for this purpose. The fund will also support the development and large-scale testing of components and processes for an efficient form of PtL production, including high-temperature electrolysis, $CO_2$ recovery from the air and innovative catalyst materials.

The global perspective is also part of the launch strategy: PtL can be produced on the most economical basis in locations where renewable electricity is both cheap and available in large quantities. A PtL system is only economical if it can be operated for several hours per year. Hence, strategies are necessary which also include other countries in the process development and production of PtL. The UBA is in favour of using the Air Traffic Innovation and Demonstration Fund to support the construction of large-scale PtL facilities abroad. The German mechanical engineering and plant construction industry will also benefit from this – as many of the components used in the PtL facilities could be "Made in Germany" in the future.

**Blending quota for PtL:** Whether synthetic kerosene is produced and imported quickly enough and in sufficient quantities ultimately depends on the costs. Even if the cost pressure increases due to the Kerosene Tax and European emissions trading, kerosene will remain significantly cheaper than post-fossil, greenhouse-gas-neutral fuels for some time.

To supplement the proposed economic measures, the UBA therefore recommends a PtL admixture quota. A quota of this kind defines the amount of sustainable PtL that the marketers of kerosene are required to add to conventional fuel. The level of the quota would be based on two factors: firstly, the time frame in which the sustainable quantities of PtL can be produced. On the other hand, the overarching goal is to replace all kerosene with post-fossil PtL fuel by 2050.

Ambitious climate protection requires rapid action. From the perspective of the UBA, the introduction of a quota appears the quickest solution to implement at the national level. At the same time, the federal government should work for a solution at the EU level. To reduce greenhouse gas emissions from air traffic to zero by the middle of the century, sustainable PtL in the range of ten to 20 terawatt hours appears to make sense for Germany as soon as the year 2030. This corresponds to roughly ten per cent of the kerosene required for Germany today.

As a first step, the UBA recommends a national PtL admixture quota of ten per cent (as measured by the energy content of the fuel). Ideally, a European admixture quota should also be sought. The resulting demand for larger quantities of sustainable PtL will reduce production costs. Of importance: to ensure greenhouse gas neutrality, strict sustainability criteria regarding the production are necessary, among others, and they must be adopted at the same time as the PtL admixture quota.

However: burning post-fossil fuels continues to emit air pollutants and water vapour at cruising altitude. Their non-$CO_2$ effects continue to affect the radiation balance of the atmosphere and influence the climate. PtL thus makes greenhouse gas neutrality possible, but it does not lead to climate neutrality for air traffic.

Tab. 03

**Overview of measures for the fuel switch**

| Measures and instruments | Latest date of impact | Who decides? | Who is responsible for the implementation? |
|---|---|---|---|
| National PtL admixture rate of 10 %, bilateral agreements with EU Member States, medium-term EU solution | 2030 | Federal government, EU Member States | Distributors of air traffic fuel |
| Setting of strict sustainability criteria for the production of PtL | 2030 | Federal government, EU Member States | Distributors of air traffic fuel |

Source: German Environment Agency (2019)

## Reducing damage to the climate: $CO_2$ and non-$CO_2$ effects

Efficiency is a decisive factor for environmentally-friendly air traffic. Efficient aircraft and jet engines reduce the need for fuel, making the PtL quota easier to achieve and the energy revolution in air traffic more cost-effective. The emissions and climate effects are reduced. In this respect, the International Civil Aviation Organisation (ICAO) plays a key role: it sets the requirements for the certification of new types of jet engine and aircraft.

**International $CO_2$ standard:** Starting from 2020, an international $CO_2$ standard will apply to air traffic for the first time. This was adopted by the ICAO in 2016 and will apply to newly developed types of aircraft from 2020 and to aircraft that has already been ordered from 2023. From 2028, older aircraft types will only be built if they comply with ICAO specifications. The determination of the standard is complex. Essentially, threshold values for fuel consumption (per passenger kilometre flown and based on a measure for the size of cabin) are set according to the maximum take-off weight.

The standard does not include an obligation to retrofit aircraft which are already in service, however. It will therefore only have a positive impact on the kerosene consumption of the aircraft fleet over the decades to come. Another problem is that it does not differentiate between aircraft weight and load and accordingly provides almost no incentives for the lightweight construction. At present, the standard is also less ambitious than the "Flightpath 2050" programme, for example, which the EU Commission and the European aerospace industry originally presented in 2011. According to Flightpath, by the year 2050 aircraft, flight procedures and energy supply are to be developed further and designed in such a way that $CO_2$ emissions per passenger kilometre are 75 per cent lower than they were in the year 2000.

Currently, the annual efficiency improvements amount to between one and two per cent. This is not sufficient for achieving the flight path goals referred to above, though. The UBA therefore recommends a more ambitious target: the efficiency of the aircraft fleet is expected to increase by two per cent per year – this also includes improvements in operational efficiency. Nonetheless, greater progress is only possible with the demanding $CO_2$ standards of the ICAO, which Germany should support at the international level.

**Reduced fuel consumption due to refuelling stops:** Take-off and landing operations use a lot of kerosene. In this respect, direct flights are usually more efficient than connecting flights. For long distances, the reverse is the case: an intermediate stop can reduce the specific fuel consumption, as less kerosene is required initially, making the aircraft lighter overall. For a Boeing 777-300, for example, a refuelling stop can reduce the specific fuel consumption starting from a distance of approximately 5,500 kilometres. As emissions during take-off and landing operations are less harmful to the climate than those during cruising flights at high altitudes, a stopover could also have a positive effect at shorter distances. Non-stop flights halfway around the world are especially inefficient. The large quantity of kerosene requires a lot of space and reduces the number of seats in the aircraft, in this way increasing the fuel consumption per passenger. A legal limitation of the tank volume could prevent exceptionally long direct flights in the future and create incentives for the construction of particularly efficient aircraft at the same time. Germany should also support such measures at the international level in the ICAO.

**Flight route management:** Detours and holding patterns increase the consumption of kerosene, and therefore levels of emissions. In the late 1990s, the European Commission launched the Single European Sky Initiative (SES). The SES aims to make more efficient use of European airspace, to restructure traffic flows and to resolve their fragmentation through national borders and interests. Since then, functional airspace blocks have been created in which air traffic can be handled on a holistic basis, regardless of national boundaries. Germany, France, the Benelux countries and Switzerland belong to the Europe Central block. It is estimated that shorter distances and fewer unnecessary queues could reduce the consumption of kerosene by 10 to 15 per cent. So far, however, the savings potential has not yet been fully exhausted. In this context, the EU is called upon to develop the potential as quickly as possible.

**Reduction of non-$CO_2$ climate effects:** In addition to $CO_2$, during cruising operations, jet engines emit particles, water vapour, sulphur and nitrogen oxides. These substances have an indirect effect, in that physical and chemical processes produce substances that alter the radiation balance, often through the formation of cirrus clouds. This effect is strongly influenced by meteorological conditions and the time of year and day.

Non-$CO_2$ climate effects can initially be reduced by flying less or by reducing fuel consumption to the minimum, and by therefore ensuring that the emissions of the aircraft used are as low as possible. These climate effects can also be reduced significantly by reducing the formation of cirrus clouds. The “flight procedures”, i.e. the standardised regulations which specify the flight path, altitude and speed to the pilot have a major influence on this. In making these flight procedures more flexible, areas and altitudes that are particularly climate sensitive could be avoided.

In addition to this, the non-$CO_2$ effects could be priced according to the polluter-pays principle with a transit fee for sensitive airspace which is based on the climate effects. In simpler terms, the climate effects could be calculated on the basis of the average meteorological conditions for a given route. Last but not least, the non-$CO_2$ climate effects could also be curbed by integration into emissions trading. In the medium and/or long term, they should be priced into the European EU ETS and the global CORSIA system accordingly. Closures or transit fees tend to be temporary solutions.

Tab. 04

**Overview of measures to reduce $CO_2$ and non-$CO_2$ climate effects**

| Measures and instruments | Latest date of impact | Who decides? | Who is responsible for the implementation? |
|---|---|---|---|
| Gradual tightening of the $CO_2$ threshold value during the aircraft certification to 45 % of the value in comparison with the year 2010 | 2050 | ICAO | Aircraft manufacturers |
| Civil supersonic aircraft are required to fulfil the applicable $CO_2$ certification requirements | 2030 | ICAO | Federal government, aircraft manufacturers |
| Limiting the fuel tank volume of long-haul aircraft to prevent exceptionally long haul flights | 2030 | ICAO | Aircraft manufacturers |
| Use of the potential through new rules appertaining to airspace (Single European Sky Initiative) to avoid detours | 2030 | EU | Air traffic control |
| Prevention of non-$CO_2$ effects through the temporary blocking of climate-sensitive areas to prevent cirrus cloud formation, or related transit fee | 2020 | EU | Air traffic control |
| Taking non-$CO_2$ effects into account in the EU emissions trading and CORSIA | 2030 | EU, ICAO | EU, ICAO |

Source: German Environment Agency (2019)

## Quieter flights: noise protection for everyone

Flying makes a lot of noise. The jet engines used on aircraft deliver enormous power, especially during take-off, and generate a corresponding amount of noise. During landing operations, even though the engines are usually idling, the air flows around the aircraft also cause considerable noise emissions. For many people in the vicinity of an airport, noise is therefore the worst effect of air traffic.

Aircraft noise certainly isn't a new problem. Modern aircraft are quieter than old aircraft because the engine manufacturers reduce the noise emissions from each new model. At many airports, however, progress has been eroded by the considerable growth in aircraft movements and the use of bigger aircraft. In the future, it will be important to make use of all the possibilities which are able to reduce aircraft noise and ergo the impact on health.

**Introduction of noise quotas:** One of the promising instruments are noise quotas, which define a maximum noise level that a person or a property can be exposed to permanently. A noise index has a similar effect, taking the number of people affected and the level of exposure per "noise level class" into account.

The advantages of noise ceilings: airlines and airport operators take the most effective and efficient measures first, as they promise the biggest step towards achieving the goal. Airports are motivated to carry out flight operations as quietly as possible so they can be able to handle as many flight movements as possible within the noise ceilings. Another argument in favour of noise ceilings is that air traffic is determined by a relatively small number of players, so that their introduction and implementation would be possible in an acceptable time frame. Last but not least, a quota system fulfils the fundamental objective of environmental policy, i.e. not to regulate air traffic itself, but to regulate its negative effects.

In any event, clear objectives are important – for example, the fact that the noise pollution must not increase any further compared with the current situation, or that a defined, maximum level of acceptable noise pollution must be achieved by a certain date. As a first step, the UBA therefore recommends capping the average noise level at 63 dB(A) during the daytime by 2030 and at 58 dB(A) by 2050.

**Ban on night flights at airports close to cities:** A special type of noise quota allocation concerns the night, because undisturbed sleep is essential for mental and physical relaxation. The UBA is in favour of phasing out regular flight operations at airports that are located close to towns and cities between 10:00 pm and 6:00 am.

Germany is closely integrated in international trade via air freight traffic – and air freight flights often take place at night. UBA considers it to be necessary that only the most urgent night flight operations are carried out, and only at one or very few airports in sparsely populated areas. This requires that the federal government carries out a superordinated planning for the German airport locations, and that these freight airports are connected to the German railway network for freight traffic. This measure cannot be implemented within a few years, but the UBA nevertheless advocates starting the planning at short notice and completing it by the year 2030. This would provide the basis for implementing a ban on night flights at all airports close to towns and cities after 2030 and for its full implementation by 2050.

**Noise abatement flight procedures:** The noise level of an aircraft isn't just determined by its age, type and size, but also the way in which it is used, i.e. its speed, thrust or flap position. It is also the case that the greater the distance from the source of noise, the lower the levels of exposure. Optimised flight procedures can therefore reduce noise – for example, by flying around residential areas or over them at a sufficient altitude, reducing the engine thrust during take-off and landing operations, or approach at a slightly steeper angle.

The UBA believes that the potential of noise abatement flight procedures at airports by 2030 should be investigated systematically, and that their detemination and use should be supported.

In practice, it is also the case that aircraft frequently deviate from flight procedures on the basis of so-called directs. This poses a problem, especially when these flight routes are optimised according to noise. From the point of view of UBA, this should only

be permitted in exceptional cases (for flight safety reasons, for example). In the future, the general public should be involved in the modification or introduction of flight procedures that have a potentially significant environmental impact.

**Noise-related take-off and landing fees:**
To be able to use an airport, airlines are required to pay money to the airport operator. The current take-off and landing fees already take noise emissions from aircraft into account. Although they require a permit from the regional air traffic authority, the individual airports can determine the exact level of such fees themselves, which is why they vary widely. Frankfurt am Main Airport, for example, is a relatively progressive airport. It differentiates according to 15 noise classes, take-off and landing times, and has adapted the tariffs so that the operation of old, noisy aircraft is particularly expensive.

Taking noise into account in these fees is the correct approach, but has been insufficient to date. Tariffs which are based on the actual noise caused by each individual flight, rather than the average noise level of all aircraft of the same type, for example, would be more effective. From the perspective of the UBA, a differentiated, polluter-pays-based charging system based on a standardised noise assessment (e. g. the same charges per dB and person) would be desirable for all airports. This does not preclude different costs per flight due to specific local circumstances at the individual airports.

**Tightening of the approval requirements:**
The permitted noise emissions for new aircraft types entering the market are regulated internationally in an ICAO Aviation Agreement. They depend, among others, on the weight of the aircraft, the engine type and the number of engines. In the past, aircraft generally became increasingly quiet. In the last few years or decades, however, these advances in noise are becoming increasingly less pronounced.

For new planes which weigh at least 55 tonnes, a stricter noise threshold value has been in force since 2018. As usual, new aircraft, and some which are already in service, comply relatively easily with the noise threshold values that are in force. Therefore, there is little incentive to develop even quieter aircraft and make them ready for service as soon as possible. Moreover, as the number of aircraft continues to increase from year to year, in overall terms, the progress made with individual aircraft is lost. From the perspective of the UBA, these noise threshold values should become a genuine objective, and not just prevent falling behind what has already been achieved.

In 2011, the “Flightpath 2050” programme from the EU Commission in cooperation with the Advisory Council for Aeronautics Research in Europe (ACARE) made the following call: the noise emissions from a new aircraft should be 65 per cent lower in 2050 than those from a comparable aircraft in the year 2000. This goal is ambitious, but achievable. From the perspective of the UBA, the federal government should work with ICAO to ensure that appropriate noise threshold values are introduced internationally in the long term, and that appropriate intermediate goals are formulated for 2030.

**Noise protection on the airport ground:** It isn't just take-off and landing operations by aircraft that generate noise: everyday airport operations do as well. Apron vehicles, such as buses, tankers or tractors are, of course, the lesser problem. Noise is primarily generated through the maintenance and repair of aircraft when their engines are started for test purposes. In this case, protective equipment such as noise barriers or noise protection hangars can significantly reduce the impact on the people living in the vicinity of airports. A major source of noise at ground level is also the auxiliary power unit (APU), which most aircraft have in their tail. In the parking position, these supply electricity for the on-board power supply and compressed air for the air conditioning system. From the point of view of the UBA, the use of APUs should be kept to a minimum. Stationary or mobile power supply facilities in the airport would be ideal, replacing the use of the APU. Hamburg Airport serves as a role model here, by prohibiting APU operations in parking positions.

**Operating restrictions for drones:** Although they seem small and inconspicuous and are something of a marginal phenomenon, they can still an irritating source of noise: drones. The existing regulations, such as the requirement for a flight permit for night flights or the limited use of drones in residential areas provide protection against the nuisance caused by small devices weighing up to two kilograms. These regulations are insufficient for larger and heavier drones, however, especially in view of the fact that logistics companies are interested in delivering parcels using drones, if possible around the clock, in the future.

Hence, effective approval requirements are urgently needed, with a limitation of the permitted noise level, which should also form the evaluation criterion of an eco-label for drones. In addition, the UBA believes that low altitude overflights over residential areas – especially at night – should be prohibited. And then there are the drones which are intended for passenger transport. These "air taxis" have similar flight attributes to helicopters. With their noise emissions at low altitudes and the potentially large number of air taxis in the future, they could lead to considerable noise pollution. Depending on the distribution and number of air taxis, the UBA therefore envisages a considerable potential for conflict in this area, and therefore a need for regulation to provide protection against noise.

**Noise protection in supersonic traffic:** Civil supersonic aircraft are currently being developed, particularly in the USA and Japan, which could be launched from around 2026. When cruising, extreme shock waves on the aircraft lead to a short but very loud bang which is audible at ground level, also at high flight altitudes. New designs of these aircraft are intended to make this bang quieter, while higher flight altitudes, lower speeds and specialist climb profiles are also intended to reduce it. The ICAO is currently developing noise protection standards for the new machines. From the perspective of the UBA, the urgent goal should be for these standards to meet the noise protection requirements currently applicable to conventional commercial aircraft during take-off and landing operations. As regards cruising flights over land, the UBA advocates a ban on flights at supersonic speeds.

Tab. 05

**Overview of noise protection measures**

| Measures and instruments | Latest date of impact | Who decides? | Who is responsible for the implementation? |
|---|---|---|---|
| Restriction of daytime noise emissions to 63 dB with a noise quota from 6 am until 10 pm | 2030 | Federal government | Federal states, airports |
| Restriction of daytime noise emissions to 58 dB | 2050 | Federal government | Federal states, airports |
| Ban on regular flight operations from 10:00 pm until 6:00 am at airports close to cities | 2050 | Federal government | Federal states, airports |
| Relocation of essential night flights to airfields in sparsely populated areas | 2050 | Federal government, federal states | Airports |
| Development and exploitation of the potential associated with noise abatement flight procedures; air traffic control approvals for flight safety reasons only | 2030 | Federal government | Air traffic control |
| Improving the determination of flight routes, in particular, regular environmental impact assessments and participation by the general public | 2030 | Federal government | Bundesaufsichtsamt für Flugsicherung |
| Increasing the steering impact of noise-related take-off and landing fees through cost allocations based on the polluter-pays principle | 2030 | Federal government | Airports |
| Tightening of the noise certification for subsonic aircraft by a cumulative 20 to 23 EPNdB compared with the current standard | 2030 | ICAO | Federal government, aircraft manufacturers |
| Tightening of noise certification for subsonic aircraft by a cumulative 28 EPNdB compared with the current standard | 2050 | ICAO | Federal government, aircraft manufacturers |
| Completion of engine testing operations in closed noise protection hangars only | 2030 | Federal government | Federal states, airports |
| Replacement of APU operations on aircraft with the on-the-ground supply for aircraft at airports | 2030 | Federal government | Federal states, airports |
| Noise approval requirements for drones and air taxis, and general night-time overflight bans for drones over residential areas | 2030 | Federal government, federal states | Aircraft manufacturers, air traffic control |
| Civil supersonic aeroplanes must comply with the applicable noise certification requirements for comparable subsonic aircraft | 2030 | ICAO | Federal government, aircraft manufacturers |
| Prohibition of civil supersonic flights over land | 2030 | ICAO, EU | Airlines |
| Supporting the development and retrofitting of light propeller aircraft for noise reduction, including electrification if possible | 2030 | Federal government | Aircraft manufacturers |

Quelle: Umweltbundesamt (2019)

## Stay grounded: train instead of plane

It is a mistake to believe that flying always saves time. In fact, destinations with a travel time of up to four hours – from centre to centre – between large cities or conurbations can often be reached just as quickly by rail. This applies to city breaks and to feeder flights to major airports, to business trips and to weekly commutes between the family home and the place of work.

**Airport connections:** One of the deciding factors in shifting short-haul flights to the railways is ensuring good links between airports and intercity rail lines to avoid the need for feeder flights. Improving intercity rail links between major cities is equally important. In this respect, the past upgrades to the high speed rail links between Frankfurt and Cologne and between Berlin and Hamburg have resulted in all of the scheduled flights on these routes being discontinued. This development is in line with the goal of the agreement of Germany's coalition government to double the number of long-distance rail passengers by the year 2030.

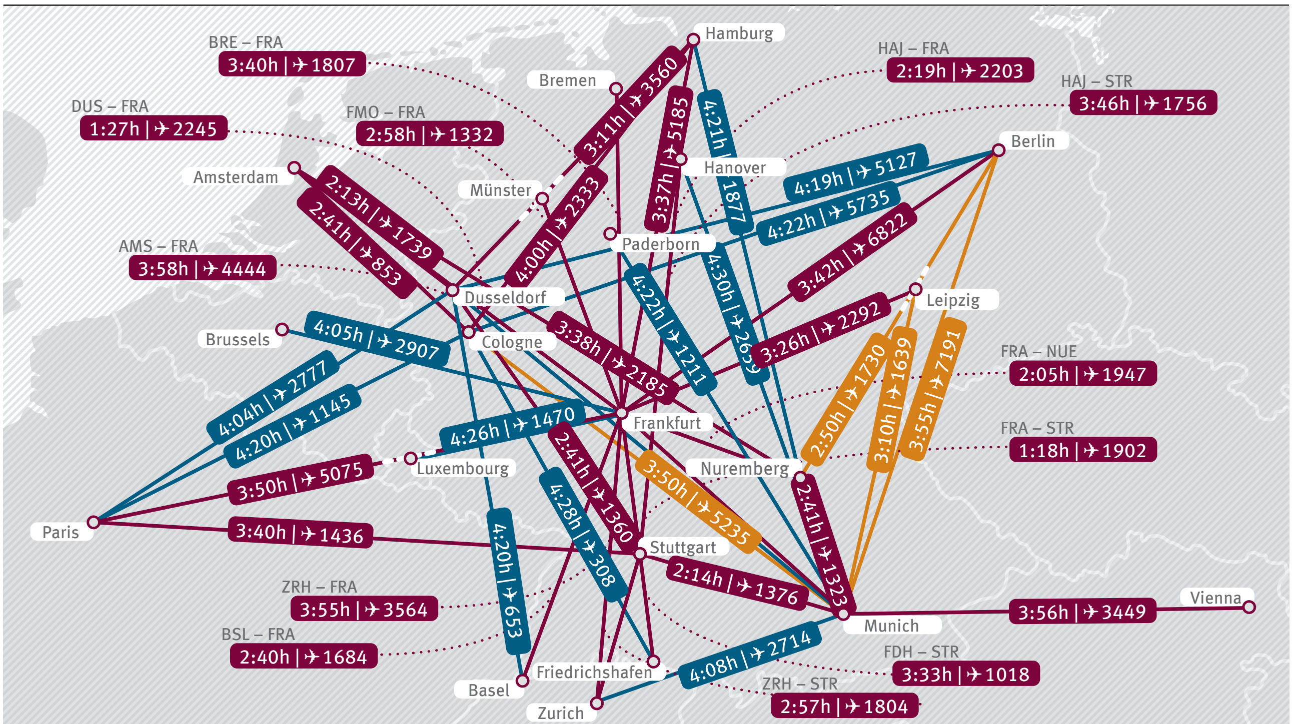
**Creating offers:** In Parncular, moving air travel to the railways is easy for connections with less than four hours rail travel time. The four-hour limit is not set arbitrarily: in the field of transport research it is considered to be a threshold time value up to which train travel is on an equal footing with air travel. The prerequisites for reaching more destinations by train in a maximum of four hours are a consistent expansion of the high-speed rail links, a comprehensive service offering, and the synchronisation of the rail connections.

The introduction of the "Deutschlandtakt" (synchronised timetable for Germany) by 2030 will make an important contribution to this. If these improvements are consistently implemented, the UBA believes that it will be possible for almost all domestic and many short-haul international flights to be shifted to rail by 2050. If all domestic flights in Germany under 600 kilometres were replaced by rail, around 200,000 flights could be dispensed of per year – corresponding to 73 per cent of domestic air traffic in Germany. In addition to the improvements in supply,

Abbildung 06

**Short haul domestic and international flights that can be moved to the railways**

of the 10 busiest airports in Germany (starting from 300 flights per year, per direction, 2014)




Accessible by train within — 4 hours — 4,5 hours — 4 hours (from 2018/2020)

1:00h | ✈1000  Train journey time | Number of flights (one direction, "starts")

Source: presentation of UBA according to data from (BUND, NGO - Air traffic concept: steps towards sustainable and environmentally friendly air traffic in Germany, 2015) the increase in the Air Traffic Tax, the introduction of the Kerosene Tax and $CO_2$ pricing via emissions trading will also result in rail travel being cheaper.

**Mobility management:** People who travel on business usually have a clear and concise agenda for their appointments. Those who plan their arrivals and departures with a similar degree of precision and in good time can often avoid the need to fly on business trips. Clear guidelines can encourage managers and employees in both public authorities and companies to choose the least environmentally damaging method of transport. The fact that this still rarely happens on an organised basis isn't due to a lack of choice over the mode of transport, but to the lack of a clearly anchored form of mobility management with defined objectives.

While companies have considerable room for manoeuvre when it comes to business trips, public authorities are obliged by the German Travel Expense Act to prioritise keeping their travel costs low. The UBA is in favour of establishing equal status between the principle of economic efficiency and environmental compatibility in terms of the choice of means of transport. In addition, telephone and video conferences should be used more often. To achieve this, however, in many cases, the technical and organisational possibilities must be significantly expanded and improved. For domestic business trips, rail should be the first choice.

The Federal Ministrys for the Environment and Transport promotes corporate mobility management through initial consultations in companies and a special support programme, for example. If air travel is unavoidable, the climate impact of the greenhouse gases released, including non-$CO_2$ effects, should be offset by voluntary compensation payments to climate protection projects. In this respect, it is essential that emissions are calculated realistically and that climate protection projects are based on high quality criteria.

**Rail freight instead of air freight:** Air freight is usually transported at night. A shift to rail is also possible in the area of national freight transport. The same applies here as it does for passenger traffic: good offers, reliability and fast connections are all of decisive importance. Superior links between airports and the German rail network as well as more intensive inter-modal cooperation between air and rail freight are essential if more goods are to be transported by rail. This applies to airports with night flights in sparsely populated regions in particular, which will mainly focus on cargo flights in the future. By 2050, the UBA also believes that efficient freight train connections could replace all national overnight freight flights.

**Sustainable tourism:** These days, people who go away on holiday usually do so by car or by plane. As global tourism continues to grow, the $CO_2$ emissions from tourism in 2035 are estimated to be 130 per cent higher than they were in 2005. Approximately three quarters of these emissions are caused by outward and return journeys, 40 per cent of which are attributable to air traffic.

Some holidaymakers plan according to the motto of "the further away, the better". Environmentally friendly travel is possible, though. The offers in this area have established themselves in recent years and a varied, professionally certified selection is available. Those looking to enjoy their holiday time near their home want convenient train and bus connections, good public transport and safe and attractive opportunities for reaching their destination by bicycle or on foot. Those who take several days off in one go have more time for a slower and more conscious outward and return journey. Night train connections also allow for journeys to distant destinations on an environmentally-friendly basis. Last but not least, the destination needs to be well considered: most exotic destinations can only be reached by air. Nearby beaches or hiking areas promise similarly enjoyable holiday time. The compulsory integration of the environmental costs in the price of the travel is of decisive importance for preventing distortions between sustainable and unsustainable travel offers. In addition to this, certification for travel also exists which travellers should be made aware on an appropriate basis.

Tab. 06

**Overview of measures shifting journeys from air to rail**

| Measures and instruments | Latest date of impact | Who decides? | Who is responsible for the implementation? |
|---|---|---|---|
| Enabling train travel times between German conurbations and airports of four hours, shifting short-haul flights to the railways | 2050 | Federal government, rail transport companies (RTC) | RTC |
| Creating efficient freight train connections, shifting overnight domestic freight flights to the railways | 2050 | Federal government, RTC | RTC, logistics companies |
| Amendment of the German Travel Expenses Act: Equivalence between the economic efficiency and the environmental compatibility of a means of transport for a business trip by federal employees | 2020 | Federal government | Federal government employees |
| Strengthening of the ecological mobility management in companies and authorities, also federal state and local authorities, including $CO_2$ compensation for air travel | 2030 | Companies, authorities | Companies, authorities |
| Improving the implementation and increased use of telephone and video conferencing as a substitute for business travel | 2030 | Companies, authorities | Companies, authorities |
| Drawing attention to environmentally friendly travel options in a suitable way, especially in terms of the choice of destination and means of transport | 2030 | Federal government | Travel operators |
| Compulsory $CO_2$ compensation for air travel | 2030 | Federal government | Travellers |

Source: German Environment Agency (2019)

## Better air quality: reducing pollutants at ground level

It isn't just flying; the operation of an airport also has an impact on the environment. Above all else, nitrogen oxides ($NO_X$), but also particles and their precursor substances pose a health risk. Previous studies have demonstrated that pollution from air traffic and airport operations can account for a significant proportion of the total pollution in nearby municipalities. Another problem is presently emerging: high levels of exposure to ultra fine particulate matter in airport environments, although a precise classification regarding the sources is currently lacking. Flight operations and ground operation management therefore have a major impact on air quality at airports and their immediate surroundings.

**Threshold values for jet engines:** The ICAO threshold value for aircraft engines should be further developed and tightened so as to achieve a 90 per cent reduction in $NO_X$ emissions by 2050 in comparison with the year 2000. This would be in line with the goal of reducing $NO_X$ set by the EU Commission and the European air traffic industry in their "Flightpath 2050" programme. In the future, the pressure ratio of the engine should no longer be used as a correlation parameter for determining the nitrogen oxide emissions, but rather its fuel consumption. The threshold values for hydrocarbons, carbon monoxide, non-volatile particles and relevant precursor substances for the formation of particulate matter must also be tightened in order to accelerate the development of low-emission engines.

**E-vehicles for airports:** The use of electrically operated ground vehicles can significantly reduce combustion-related emissions. The full or at least partial electrification of ground vehicles is technically possible, and presents an obvious option for reducing air pollution. This applies to apron buses, passenger cars and light commercial vehicles, as well as specialist airport applications, such as lift trucks, aircraft tugs, container transporters, mobile passenger staircases or lift vehicles. As the use profiles of the vehicles are often well known, a customised configuration of the performance data for electric battery-powered operation is not a problem. E-vehicles, for example, are being tested in the "E-PORT AN" project at Frankfurt Airport; at Munich Airport, more than 280 vehicles and ground handling equipment are also powered by electricity. The electrification of the vehicles on the airport apron would be easy to implement and should be completely realised at airports in Germany by 2030.

**Pollutant-based take-off and landing fees:** The take-off and landing fees levied by an airport must take noise protection factors into account according to the Air Traffic Act. Furthermore, according to the law, a differentiation should be made according to pollutant emissions. This target specification will be implemented at various German airports. The airport operators will levy additional fees, mainly on $NO_x$ emissions, but also on hydrocarbon emissions. The fee will be payable for emissions per engine and based on the ICAO take-off/landing cycle. The UBA is convinced that emissions of (ultra)fine particulate matter should also be taken into account by 2030 at the latest. Pollutant-based fees should be introduced at all German airports and measured according to the level of local external costs to the environment.

Tab. 07

**Overview of measures to reduce local air pollutants**

| Measures and instruments | Latest date of impact | Who decides? | Who is responsible for the implementation? |
|---|---|---|---|
| Conversion of all ground vehicles and handling equipment on airport aprons to electrical operation | 2030 | Federal government | Federal states, airports |
| Collection of $NO_x$-based take-off and landing fees at all German airports, cost allocation according to the polluter pays principle, introduction also for (ultra)fine particulate matter and their relevant precursor substances | 2030 | Federal government | Federal states, airports |
| Replacement of APU operations on aircraft with the on-the-ground supply of aircraft at the airport | 2030 | Federal government | Federal states, airports |
| Gradual tightening of the air pollution certification requirements for aircraft engines (in particular $NO_x$ emissions, by 90 % compared with the year 2000) | 2050 | ICAO | Federal government, aircraftmanufacturers |

Source: German Environment Agency (2019)

# The air traffic of the future: looking ahead


6

# The air traffic of the future: looking ahead

In air traffic, all the signals currently point to “more”: more aircraft, more passengers, more cargo, more aircraft movements. Yet, this also means that greenhouse gases, air pollutants, noise and land consumption are continuously increasing. “Continuing as before” is therefore not possible. Answers are required to the current and future environmental challenges.

Air traffic has always been subject to a considerable number of agreements, regulations, rules and standards. What has been missing so far is a similarly consistent and coordinated approach in terms of its environmental and climate compatibility. As long as people and the environment are affected by air traffic, it must be regulated at an environmentally compatible level. With the numbers of flights increasing all the time, the aircraft and engines, fuel, flight procedures and demand analyses for airports must be assessed regularly at the legal and/or statutory levels.

Time is of running out: air traffic is also required to comply with the climate goals determined in Paris. Although the European emissions trading system and the planned global climate protection mechanism of CORSIA constitute approaches for a greater degree of climate protection, they do not yet promise a noticeable reduction in global net greenhouse gas emissions. The costs to the environment and to human health caused by air traffic must be more consistently charged to the polluters, through global certificate trading, for example. Emissions from the fossil fuel of kerosene must be gradually reduced to zero by 2050.

Ambitious solutions need a lot of time. The progress will thus depend on the instruments that the politicians and the air traffic industry implement, and within which deadlines. Germany and Europe must lead the way and act as role models for other countries. The initial steps, for example, are increasing the Air Traffic Tax and introducing a nationwide Kerosene Tax for domestic flights. These steps would reduce the unjustifiable competitive advantages of air travel over rail travel in Germany. If the railways were to offer comparably fast and convenient alternatives, short-haul, feeder and domestic flights could become completely superfluous. Consequently, expanding intercity rail network and connecting airports to the rail network are of key importance.

The increase in the Air Traffic Tax and the introduction of a kerosene Tax, which should be introduced throughout the EU as soon as possible, have not yet created any $CO_2$ pricing for air traffic. Internalising non-$CO_2$ climate effects also makes sense. Additional and stricter requirements in the area of European Emissions Trading and the consideration of non-$CO_2$ effects in the trading system are therefore necessary. In the long term, global emissions trading for air traffic must be the goal.

New, sustainably produced fuels which are launched on the market as quickly as possible are an important part of the energy transition for air traffic. By 2030, approximately ten per cent of the fossil fuel of kerosene should be replaced by Power-to-Liquid fuel (PtL). This requires consistent action at several levels: regulatory flanking through a domestic, and subsequently European PtL admixture quota, state support for the development and testing of systems and their components at home and abroad, the establishment

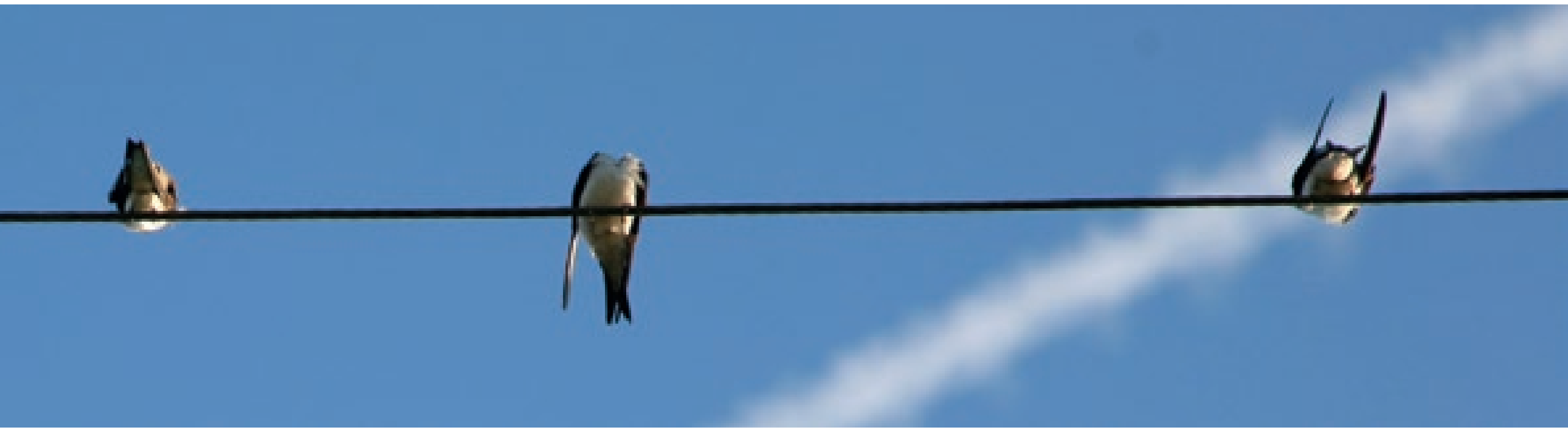
of an “Air Traffic Innovation and Demonstration Fund” which actively supports and accelerates the necessary developments for sustainably produced PtL and which also supports alternatives to flying, through social innovations, for example.

In addition to greater sustainability and climate protection, environmentally friendly air traffic also requires one thing in particular: consistent noise protection for all of those affected. The list of possible measures is long, but consistent noise protection requires a combination of the environmentally-oriented planning of the air traffic system in Germany and noise quotas for the individual airports. In specific terms: the management/development plans of airport locations must be carried out more strongly than before by the federal government. Specific use will be made of locations in sparsely populated areas for only those night flights which are absolutely necessary; at airports close to cities, regular flight operations will be completely suspended between 10 pm and 6 am. Noise quotas offer two possibilities: on the one hand, airports can continue to grow – provided that they use quieter aircraft and flight procedures. On the other hand, operators gain sufficient leeway for taking the most cost-effective noise protection measures.

Despite the variety of possible instruments for low-noise, climate- and environment-friendly air traffic, some individual factors remain unresolved. This includes dealing with the so-called the non-$CO_2$ effects of air traffic. Even with integration into emissions trading, optimised flight procedures or renewable fuels, these cannot be completely prevented. This means that air traffic itself won’t be climate-neutral, even in 2050.

This invariably leads to the following question: from the perspective of the costs to the environment and the climate, can we really afford the continued growth of air traffic? After all, in air traffic, “rebound effects” are the rule. While it is true that technological advancements lead to improvements for individual aircraft, for certain routes and for processes at an airport, the positive effects are cancelled out by the strong growth in traffic. Or expressed at the level of the individual traveller: are the planned holiday or business flights really necessary?

Everyone knows the answer. flying isn’t always necessary. At least, not so often and not so far. And not on an unplanned or ill-considered basis. On the contrary, a sustainable society requires a high-quality and sustainable transport system which transports people and goods in compliance with the environmental quality objectives and social standards. This benefits everyone, not only the environment and the climate. And it also benefits industry by eliminating unfair competition, promoting cooperation and exploiting efficiency potentials. And above all else, it benefits travellers who want to reach their destination safely and reliably, and in a way that is environmentally- and climate-friendly.

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