# Reinventing Flying

February 2020

The aviation sector is facing turbulent times, with increasing regulation, rising costs, critical passengers and technical problems presenting major challenges for airlines.

What is the future of flying? We take a look ahead.

# Contents

# 1 Introduction

## A sector in turmoil

Twenty years from now, will electric jets be carrying 300 passengers from Frankfurt to New York? While cars made by the likes of Tesla mean that the fantasy of a future where all ground transport is electrified no longer seems far-fetched, it is still beyond imagination in aviation. At the same time, the idea that climate change will bring an end to flying by 2040 seems just as absurd as the possibility that aircraft will continue to burn vast quantities of kerosene. So, what does the future hold for flying? What are the solutions for a sector where competition is intense and constant cost pressures are a defining feature?

Tighter regulation in response to rising global $CO_2$ emissions has further aggravated an already difficult environment for airlines. The discussion in society about whether civil aviation still makes sense (flight shaming) is another potential burden for the industry, and the airlines' 'licence to fly' appears to be under threat.

Against this backdrop of change and uncertainty, it is often forgotten that civil aviation is still a growth area, especially in emerging markets. Demand for more transport options remains high.

In this context, investors have to ask themselves which companies have the best response to the changing external factors and higher costs. And which are successfully using the growth of the industry to present themselves in a positive light compared to the competition?

This paper first examines the regulatory framework and then focuses on technological innovations in aircraft construction and fuel. Finally, it takes a look at the future of flying, at new applications and at alternative transport and logistics concepts.

# 2 Civil aviation is still a global growth market

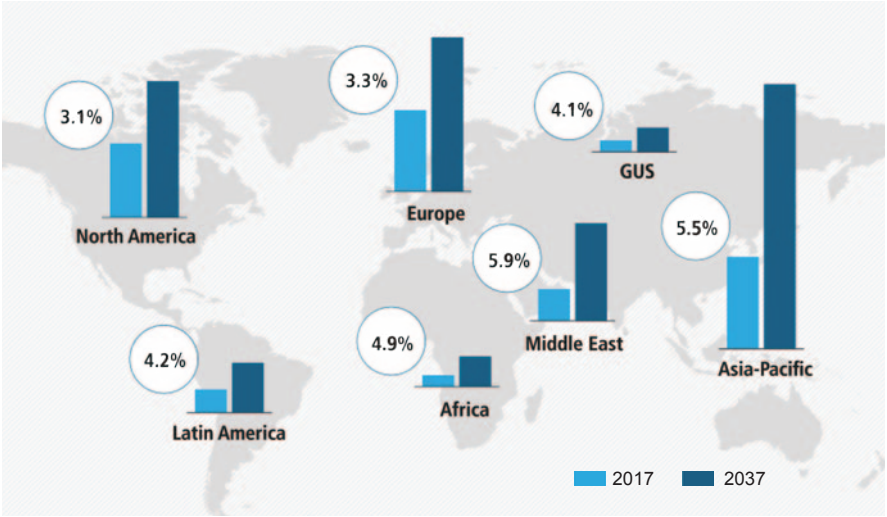
Growth unabated despite headwinds

Civil aviation is the fastest-growing mode of transport worldwide. The International Air Traffic Association (IATA) predicts annual revenue increases of 3.7 per cent up to 2037, and the number of passengers per year could almost double to around 8.2 billion over this period. The main driver will be the rise in passengers from Asia and the Middle East. Figure 1 shows the regional growth predictions. Accordingly, demand for airplanes remains high, not least due to a substantial pent-up demand in the expanding emerging markets, while new airplanes featuring

innovative technologies allow companies to rejuvenate their fleets and increase efficiency. This is particularly important with regard to kerosene consumption and $CO_2$ emissions.

Figure 1 **Regional growth around the world**

Growth in traffic between 2017 and 2037 in passenger kilometers, by world region




Source: https://www.umweltbundesamt.de/sites/default/files/medien/1410/publikationen/uba_fb_wohin-geht-die-reise.pdf, Umweltbundesamt

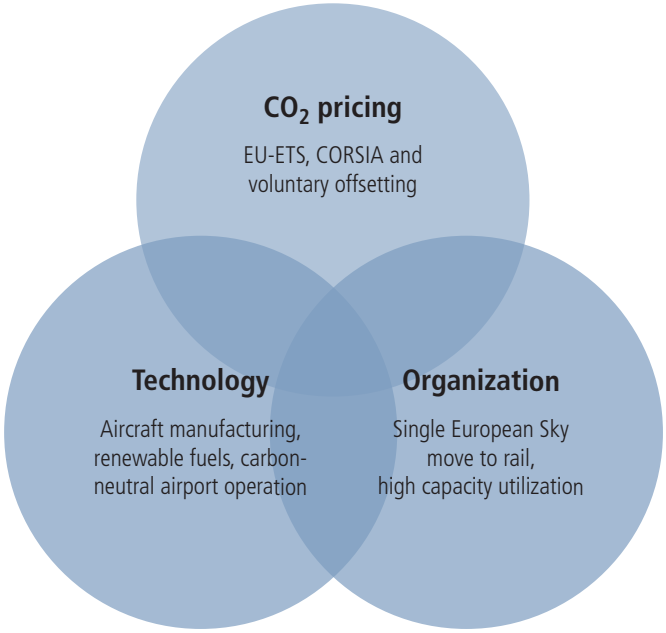
That is all well and good for airlines and aircraft manufacturers, but as a consequence of this unfettered growth the absolute volume of $CO_2$ emissions from civil aviation is also increasing. And this despite the fact that airlines have already been continuously improving their $CO_2$ efficiency for some time.

$CO_2$ emissions are also increasing

While the aviation sector currently accounts for only around 2.8 per cent of global $CO_2$ emissions, that figure is set to rise. By 2040, the aviation industry is likely to be the sector contributing most to global demand for petroleum-based products. According to calculations by the International Energy Agency (IEA), the aviation industry would have to achieve annual efficiency gains of 3 per cent by 2040 to meet the Paris climate targets. Between 2014 and 2016, it only managed to achieve efficiency gains of around 1 per cent a year. The prospect of meeting the targets set in Paris is still a long way off.

The operational success of companies is in conflict with the need to reduce their carbon footprint. If the aviation sector wants to maintain its fundamentally positive prospects in the long term, it must decouple future growth in the volume of traffic from the associated emissions. It appears that $CO_2$ emissions can only be reduced – and the 'Net zero emissions by 2050' project be achieved – through a combination of innovative technology, regulatory requirements for pricing $CO_2$, and improved organisation and logistics throughout the transport sector.

Figure 2 **Instruments for reducing $CO_2$ emissions in aviation**




Source: Union Investment

# 3 Regulatory challenges

In order to comply with the Paris Agreement's requirements to limit the rise in temperature to a maximum of two degrees Celsius, agreements and regulations are being pushed through and implemented at national and international level.

## 3.1 Regulations in Germany

National and …

In Germany, the climate package recently passed by the German government includes several regulations designed to reduce $CO_2$ emissions in the aviation industry. These include making rail travel more attractive and supporting new, more $CO_2$ efficient fuels, which are also to be used by aircraft in the future. The package also incorporates an increase in air transport levies and a ban on dumping, especially on short-haul routes. This national climate package complements the existing European rules on trading $CO_2$ certificates.

## 3.2 Application of the EU ETS and its impact on the aviation sector

…European efforts to reduce $CO_2$ emissions have a combined effect

Since 2012, flights starting and ending within the EU have been covered by the European Union Emissions Trading Scheme (EU ETS). The ETS is the EU's main tool for meeting its climate policy goals. This market-based instrument is designed to achieve a 43 per cent reduction in $CO_2$ emissions by 2030 compared with 2005 in sectors such as power generation and industrial production plants.

Until 2016, the ETS only exerted limited financial pressure on airlines due to the low price of $CO_2$. The continual reduction of the $CO_2$ cap combined with a system-related shortage of available $CO_2$ certificates since April 2017 caused the price of $CO_2$ to rise again. The average price in 2018 was €15; currently companies have to pay around €10 more per certificate. For the first time in more than a decade, the ETS is presenting European airlines with a financial challenge – but it is also having the desired effect.

The cost of $CO_2$ certificates will affect airlines more severely in the future

The EU ETS has been designed in such a way that the $CO_2$ price is expected to rise for the aviation industry due to the continual reduction of the $CO_2$ cap combined with the shortage of available certificates. At the same time, the sector's $CO_2$ emissions will increase by around 2.5 per cent annually. Assuming a $CO_2$ price of €25, the cost to airlines could amount to more than €1 billion in 2019, almost twice as high as in 2018. Even higher $CO_2$ pricing in the ETS will increase costs further, representing an ever-larger expense for the affected airlines. These companies need to find a solution as a matter of urgency.

The EU abandoned its plan to incorporate air traffic between the European Economic Area and non-EEA countries into the EU ETS following strong resistance from international airlines and in view of the climate protection negotiations within the International Civil Aviation Organization (ICAO). The ICAO has already developed a global, market-based system for limiting emissions from aviation: CORSIA (Carbon Offsetting and Reduction Scheme for International Aviation).

## 3.3 CORSIA

International agreement to reduce $CO_2$ emissions based on offsetting models

As a rule, international agreements to limit global $CO_2$ emissions from civil aviation are always preferable to local solutions. Because of the high volume of air traffic in the United States and the strong growth in Asia and the Middle East, it is crucial that these countries and regions are included in a binding agreement to reduce $CO_2$ emissions.

It was agreed in the Kyoto Protocol that the International Civil Aviation Organization (ICAO) should regulate targets and instruments to reduce $CO_2$ emissions. In 2016, the ICAO decided to introduce the CORSIA $CO_2$ pricing instrument with the objective of capping the future rise in $CO_2$ emissions from international aviation at the 2020 level. This means that CORSIA will not limit future $CO_2$ emissions per se; it will only limit further growth.

Not enough offsetting projects available

Under CORSIA, airlines will make payments, known as carbon offsets, for any emissions that are too high. The income from CORSIA is to be used to finance a range of projects to reduce $CO_2$ emissions, such as reforestation programmes. What CORSIA lacks so far are binding standards for how the rise in $CO_2$ emissions, in particular, is to be limited. The number of projects is also insufficient to achieve a significant reduction in $CO_2$ emissions.

When the CORSIA programme launches in 2021, more than 80 countries will take part in a voluntary pilot phase that runs until 2026. This means that almost 80 per cent of international air traffic will be covered by CORSIA, although the key growth markets of India and China are not on board so far. From 2027, CORSIA will be binding for all countries that accounted for more than 0.5 per cent of global air traffic in 2018. The associated payments should offset around 90 per cent of growth-related $CO_2$ emissions.

There is the option for CORSIA to replace the EU ETS in the aviation sector from 2023 if the European participants deem it equally effective at protecting the environment. It should be noted that CORSIA only freezes the growth in emissions at the level of 2020, whereas more ambitious climate protection programmes in individual countries aim to reduce emissions below the 1990 level. The ETS with its higher $CO_2$ pricing already has a more climate-friendly effect, so it seems unlikely that CORSIA will replace the EU ETS in Europe.

## 3.4 Implications of the proposed regulations for airlines

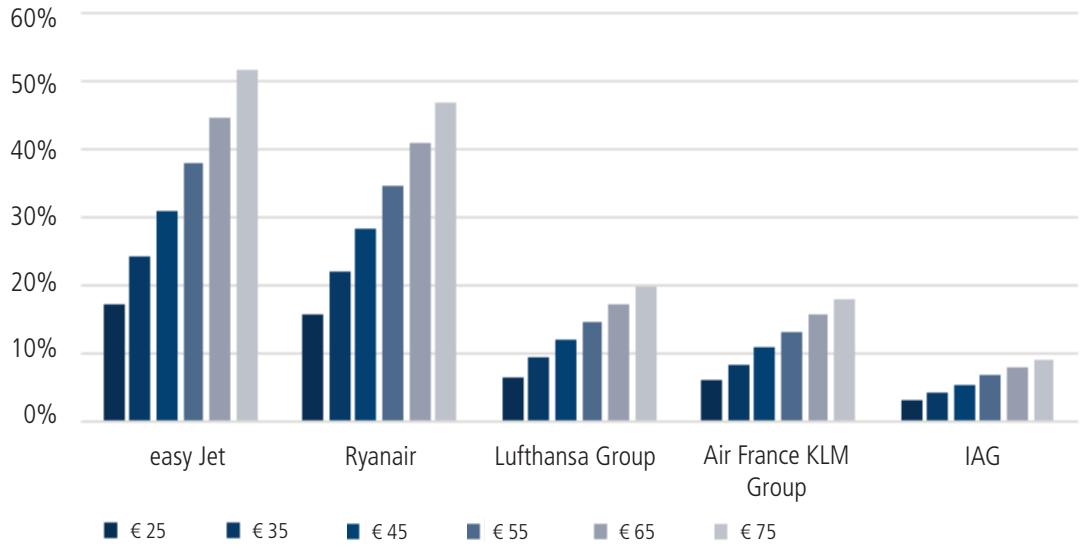
Regulation affects European airlines in particular

All national and international rules and regulations mentioned so far represent an additional cost for airlines that directly impacts on their balance sheet. Figure 3 illustrates how various $CO_2$ prices in ETS could affect airlines' profits.

In 2018, European airlines paid more than half a billion euros for $CO_2$ certificates in the EU ETS, with the major airline groups accounting for three quarters of these. Ryanair paid the most, €85 million, of all airlines for $CO_2$ certificates, ahead of the Lufthansa Group with €79.6 million. The International Consolidated Airline Group (IAG), which includes British Airways, Iberia and Aer Lingus, had the third-highest expenses at €51.4 million, followed by easyJet and Air France-KLM, each spending around €50 million on emissions certificates. It is clear that the costs have reached a level at which the companies simply have to react, especially as a further rise in the price of $CO_2$ certificates is expected.

Figure 3 **Estimated, absolute ETS costs for a range of $CO_2$ prices (€/tonne) as a share of EBIT in 2019E**

Potential impact of $CO_2$ prices on airline profits




Source: Credit Suisse

Low-cost carriers (LCC) most affected by the EU ETS

Due to their high share of flights within the EU – which are completely subject to the EU ETS – and comparatively high growth rates, low-cost carriers (LCC) such as Ryanair and easyJet are particularly exposed to this regulatory risk, as shown in figure 3. LCCs in Europe are also disproportionately affected by national levies on short-haul flights and the ban on dumping.

CORSIA's potential financial impact on airlines also depends on their growth rates, their efforts to reduce $CO_2$ emissions and the future price of $CO_2$. MSCI has analysed CORSIA's potential financial impact on the leading airlines, and its research shows that it will be relatively low in the first few years. That will not change until 2033, when the proportion of $CO_2$ growth to be offset will rise from 20 per cent to 70 per cent for each individual airline. Due to its more comprehensive regional structure, CORSIA – unlike the EU ETS – will also affect airlines that do not have their operational focus in Europe and offer intercontinental flights. CORSIA will therefore have a lesser impact on LCCs, but it will have consequences for airlines whose international flights are not covered by EU ETS, such as Air-France-KLM and IAG, in particular.

Regulations are having an incentivising effect

Both types of regulation should exert an incentivising effect on airlines. The EU ETS and CORSIA challenge them to find a way to reduce their $CO_2$-related costs. By doing so, airlines are not only supporting their future operational growth but also consolidating their market position against less agile competitors.

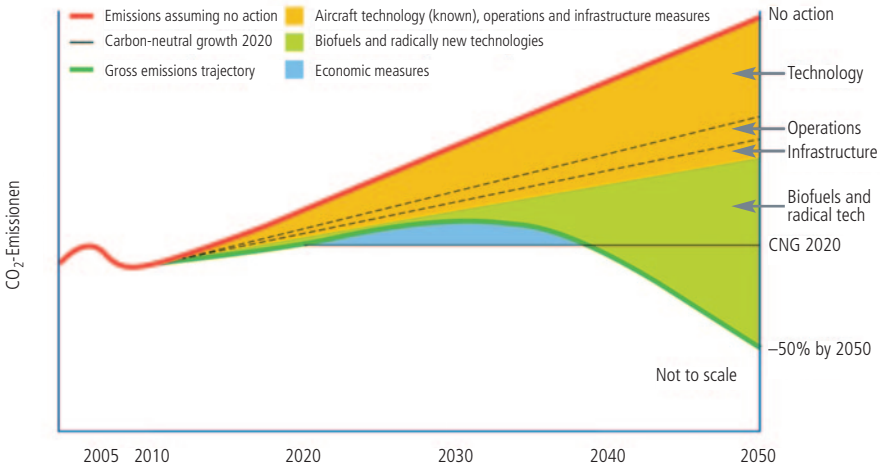
Alongside the negative cost effects of regulation, the critical public debate on $CO_2$ emissions poses an additional threat to airlines. Increased environmental awareness could negatively affect the sector's growth prospects over the medium-term. It is likely that private and business customers will pay more attention than before to their carbon footprint, particularly on short-haul routes, and choose alternative means of transport like rail. A survey of air passengers confirms this trend, which represents a risk for airlines (see UBS study 'Consumers' climate awareness on the rise; assessing the impact on traffic and planes demand', September 2019). The same survey also shows that passengers would be willing to fly short haul if airlines manage to reduce their emissions in the future. The results of this study put pressure on airlines to solve their $CO_2$ problems.

# 4 Ways out of the crisis

The good news is that there are ways to respond to higher cost pressures and the changes in consumer behaviour. The bad news is that these approaches cannot be implemented immediately and depend on developments outside of the traditional aviation sector. If airlines are to meet ambitious regulatory requirements and equip themselves for future challenges, they will need to take action in several areas, as shown in figure 4.

In the medium to long term, the most promising way of reducing aviation's negative impact on the environment is to industrialise alternative fuels (green area in figure 4). Technological developments in the field of hybrid and electric propulsion are more long-term solutions, and mainly for short-haul flights. In the short term, airlines can react to regulation and cost pressures by keeping the age of their fleet down and relying on more efficient engines (the yellow area represents the sum of all technological innovations; additionally, there are logistical adaptations, which are explained in point 5). As well as deploying new technology, airlines can improve their carbon footprint through offsetting.

Figure 4 **Relevant factors affecting $CO_2$ reduction**




Source: IATA

Various initiatives will need to have a combined effect

## 4.1 Greater efficiency through the modernisation of fleets and engines

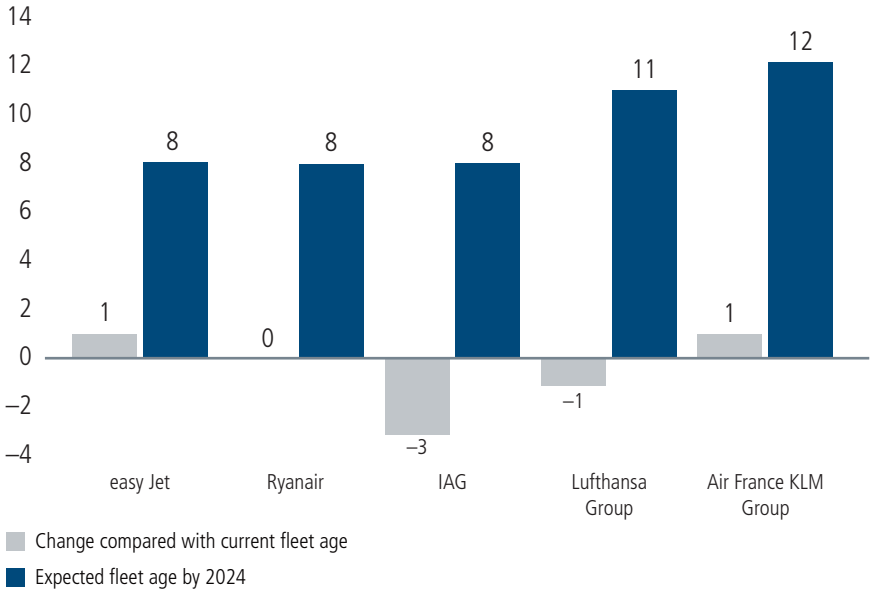
Investment in more energy-efficient aircraft is an essential means of reducing $CO_2$ emissions. On average, each new generation of airplanes uses 25 per cent less kerosene and emits correspondingly less $CO_2$. New engines, optimised aerodynamics and lower weight are particularly effective technical features in this respect. To take advantage of these efficiency gains, German airlines have recently ordered around 210 airplanes with lower fuel consumption at a total cost of €42 billion.

## Aircraft fleets need investment and innovation

Aircraft manufacturers are key partners for the airlines, and they too are faced with constant pressure to innovate. Only by working closely together can airlines and manufacturers continue to achieve the necessary $CO_2$ reductions. The major global players Airbus and Boeing are the main beneficiaries of the ongoing demand for aircraft.

So far, it is the LCCs in Europe that have been reaping the benefits of their relatively young and efficient fleets. An analysis of the five largest European airline groups' current fleets and aircraft orders reveals that this will change over the next five years. Figure 5 shows that with an average age of eight years, IAG's fleet will match those of the LCCs. As it stands, Air France-KLM and Lufthansa are likely to have the oldest fleets of all major European airlines by 2024.

Figure 5 **Forecast of the average age of aircraft fleets by 2024**




Source: Credit Suisse

Renewing these fleets will be all the more crucial if the new European Commission adopts additional measures as part of its European Green Deal to reduce aviation emissions in Europe more effectively than the EU ETS has managed so far. It is clear that the basic trend is towards additional financial costs for air travel within Europe.

New propulsion technologies also have great potential to reduce emissions, in particular by improving the bypass ratio. A few engine manufacturers dominate the market in this area, including General Electric, Pratt & Whitney (United Technologies), CFM International and Rolls-Royce in the UK. The leading manufacturer at the moment is Pratt & Whitney. The Pratt & Whitney PW1000G engine family, a joint development with DAX-listed German manufacturer MTU Aero Engines, is highly successful on the market thanks to its comparatively low fuel consumption, emissions and noise levels.

The latest engine developments show, however, that further significant efficiency gains are unlikely in the short term. In particular, the materials used offer little scope for further optimisation and adjustment. This means that additional efforts in other areas are crucial.

## 4.2 Possible alternatives to fossil kerosene in aviation

Lufthansa CEO Carsten Spohr is not alone in believing that synthetic fuels offer the most promise for the aviation sector to be as carbon-neutral as possible in its operations. Sustainable aviation fuels (SAFs) have the potential to lower the sector's emissions by 20 to 95 per cent, depending on how they are manufactured and blended.

Sustainable aviation fuel (SAF) promising for $CO_2$ reduction in the medium term

SAFs can be made from organic material and using renewable energy. They are currently designed as drop-in fuels and can be blended with conventional kerosene. There are two main variants:

- Hydroprocessed esters and fatty acids synthetic paraffinic kerosene (HEFA-SPK) is made from waste fats, vegetable oils or algae. Currently, this is the only fuel that is mature and fully commercialised, and in the short and medium term it will be the most important biofuel in aviation. Over the entire lifecycle, its use could reduce greenhouse gas emissions by up to 80 per cent when compared with fossil kerosene. The leading listed company in this field is Neste, based in Finland. Its renewable diesel fuel is already being mixed with regular diesel for use in lorries, but it can also be used in aviation. Neste is working on alternative biofuels with other oil companies and airlines, including Lufthansa and BP.

  This type of fuel is mainly made from waste, and it generates significantly less $CO_2$ than kerosene when burned. It makes sense – economically and environmentally – for airlines to blend it with their regular fuel, especially on long-haul flights.

  Its main drawback is a lack of capacity. There simply are not enough input materials for production to largely replace fossil fuels (kerosene). Nevertheless, the product is currently a suitable option for blending. Companies that proactively formed forward-looking partnerships should have a head start over their competitors on the way to an improved carbon footprint, as they will have been able to secure scarce fuel capacities in good time.

- In the power-to-liquid (PtL) process, $CO_2$ is combined with hydrogen using renewable energy to make a synthetic crude oil. For this reason, the end products are also known as e-fuels. As the $CO_2$ released into the atmosphere during the flight was absorbed while producing the fuel, the process is carbon-neutral overall. The future should belong to this product, even if it is not market-ready yet, as the necessary input materials are available in far greater quantities. There are huge opportunities here for German companies, such as Siemens and ThyssenKrupp, to build the PtL plants needed to manufacture these synthetic fuels. Energy partnerships like the one between Germany and Morocco, and funding for projects such as the Green Energy Park in Ben Guerir, underline the efforts in – and hopes for – this area. According to studies conducted by the ICAO, replacing regular kerosene with alternative green fuels should be possible by 2050, provided that around 170 new PtL production plants are constructed a year. That would require annual investment of US$ 15 to 60 billion. Many partnerships already

exist in this field. In February 2019, for example, Lufthansa agreed a strategic alliance with the northern German refinery Heide, whereby wind power will be used to produce synthetic kerosene as part of a €4.2 million research project. A pilot plant is set to come on stream at the end of 2023, covering 5 per cent of Lufthansa's fuel needs at Hamburg Airport.

The price of SAF is still higher than kerosene

Both alternative fuels are still two to three times more expensive than regular kerosene. According to the IEA, the manufacturing costs are around US$ 0.70 to 1.60 per litre of biofuel, whereas regular kerosene can be produced for around US$ 0.25 to 0.60. And because PtL is still in the early stages of development, its cost per litre is even higher at US$ 1.00 to 2.50. However, given the climate emergency and the considerable sales potential, there could be political support for commercialisation, particularly in Europe.

Also under discussion are fixed blending quotas to further encourage the use of SAFs. At around 15 million litres, biofuels accounted for less than 0.1 per cent of total aviation fuel consumption in 2018. Increasing this quota is both sensible and necessary. It would not only significantly reduce $CO_2$ emissions, but would also bring down the cost of manufacturing SAFs considerably thanks to economies of scale.

### 4.3 Hybrid and electric drives – alternative technologies of the future

Another option for reducing $CO_2$ emissions is the development and use of alternative propulsion technologies. Fully electric and hybrid drives, in particular, play an important role here, and fuel cells could also be used in aviation in the future. But these technologies will mainly be used in smaller planes and on shorter routes. Just as in the automotive sector, the 'right' battery will be crucial to commercial application. Companies in the automotive and aviation sectors have the common goal of developing and using more efficient battery technologies to improve the $CO_2$ balance of both transport segments.

There are already around 100 research programmes worldwide that aim to make electric flight possible, twice as many as in 2016. The biggest challenge for the researchers is the weight of the batteries, which is why fully electric drives are currently only realistic in very small aircraft types and over short distances (30 to 50 passengers, range of around 500 kilometres). Batteries that use liquid lithium-ion, in particular, are quite heavy and often do not meet the strict aviation safety regulations. The (distant) future of battery technology could therefore belong to solid-state batteries, which are lighter and more durable than conventional types and, most importantly, safer. The drawback with this technology is the lower conductivity of the solid electrolytes, and a lot of time and money is being spent on improving this. However, it will be some years before we can expect a market-ready solution.

Electric drives mainly expected on short-haul flights in the medium term

Hybrid drives – comparable to those used in cars – are regarded as a key technology on the way to realising electric flight. There are many partnerships and alliances working on this technology of the future. Airbus, for example, has joined forces with Rolls-Royce as part of the E-Fan X programme to develop a hybrid-electric concept aircraft for 100 passengers. Its first test flights are scheduled for 2021. Rolls-Royce is seeking to become the leading manufacturer of hybrid and electric drive systems. This year, it announced the takeover of Siemens' eAircraft division, securing key technologies and expertise in this field for the company. The Californian start-up Wright Electric is working with easyJet to develop alternative propulsion systems for larger passenger airplanes. They plan to launch a hybrid-electric aircraft for up to 186 passengers by 2030, which will resemble an Airbus A320 and could be used on routes such as London to Amsterdam.

A lot of research is also going into fuel cell technology. The US company ZeroAvia, for example, is hoping to bring a hydrogen-based system to market in 2022 as a replacement engine for existing aircraft fleets. And the German Aerospace Center (DLR) is currently developing aircraft powered by fuel cells. The researchers believe that hydrogen-powered aircraft for up to 80 passengers and distances of up to 2,000 kilometres could be feasible in 15 years' time.

Fuel cell technology not yet market-ready

These alternative propulsion types also play an important role in new transport concepts, including flying taxis and ultralights, with the first market-ready versions expected some-time between 2022 and 2024. MTU, for example, acquired a stake in e.SAT this year, a company that develops small aircraft with electric drives for use as flying taxis. In March, Airbus presented the CityAirbus, a vertical take-off and landing (VTOL) aircraft that successfully completed its unmanned maiden flight in Bavaria last year.

## 4.4 Carbon offsetting models

Offsetting is back in fashion

Schemes that allow companies to invest in environmental projects to offset their own carbon footprint have been around since 2005. This carbon offsetting has been compared to the selling of indulgences. These schemes fell out of fashion in the early 2010s when the 'moral hazard' behaviour of many market participants came under fire. Some of the projects and initiatives were also unable to deliver the promised results.

Today, offsetting models are experiencing something of a renaissance. The planned CORSIA agreement is one of the reasons why companies are again looking to improve their carbon footprint through offsetting. There are two different types:

- The company pays for its $CO_2$ emissions or supports projects that reduce global $CO_2$ emissions (CORSIA approach).
- The consumer actively decides – for example, in connection with a flight – to offset their own carbon footprint.

Air passengers already have the option to pay to offset the emissions from their flight and make it essentially carbon-neutral. The climate protection organisation Atmosfair reported that it received €9.5 million in offsetting payments in 2018, a year-on-year increase of 40 per cent. In 2019, that amount doubled.

There are plans to make offsetting easier for individuals and companies. According to the German Aviation Association (BDL), German airlines will incorporate options for carbon offsetting and supporting sustainable environmental projects into the booking process. Lufthansa and easyJet, for example, have expanded their carbon offsetting programmes. For some business flights, Lufthansa has even chosen an offset model in which the ticket price automatically includes a payment for carbon offsetting. The airline also launched its own online platform for offsetting, Compensaid, on 19 August 2019.

Furthermore, the aviation industry is proposing that legislators facilitate the existing tax deductibility of carbon offset payments. Specifically, the deductibility that individuals already enjoy should be extended to business customers. This would be a further step that would significantly increase the acceptance of carbon offsetting.

It is also important to understand how carbon offsetting works. For example, easyJet announced in November 2019 that it will offset $CO_2$ emissions for all passengers and all flights. But scientists pointed out that this would by no means make easyJet flights climate-neutral, because the negative impact of flying goes far beyond $CO_2$ emissions. Water vapour, nitrogen oxide and other emissions also affect the climate, especially at high altitudes. According to the German Environment Agency, aviation's real impact on the climate is more likely to be three times greater than just the $CO_2$ emissions alone. While

the term 'net-zero carbon flights' used by easyJet is technically correct, the impact of flying on the environment is not zero overall. Payments are only made to offset $CO_2$ emissions, and this must be taken into account in the discussion of $CO_2$ offsetting models.

The number of offsetting models is increasing, but there are not enough projects

A further, fundamental problem with offsetting is that these schemes are also used in sectors other than aviation, such as energy and utilities. As a result, the number of projects is too small to implement all offsetting schemes. Due to this lack of capacity and for logistical reasons, it is impossible to make aviation completely carbon-neutral in this way. However, in the short to medium term, these initiatives can play their part in reducing $CO_2$ emissions. Projects are more varied and are run more professionally now than they used to be, and the majority boast transparent certification. Sensible concepts and projects mainly aim to

- support reforestation;
- stop deforestation;
- reduce $CO_2$ emissions from agriculture;
- and protect peatlands.

The reputation of carbon offsetting models as being a way of buying a clear conscience for an unsustainable lifestyle therefore seems a little undeserved. Together with the initiatives outlined above, they can help to reduce overall $CO_2$ emissions from aviation.

# 5 Complementary approaches to improving aviation's carbon footprint

Alongside airlines and aircraft manufacturers, there are many other areas which, taken together, could contribute to a significant reduction in carbon emissions in the aviation sector:

- Germany's airports are already making a valuable contribution to reducing $CO_2$ emissions on the ground. Between 2010 and 2018, they cut their $CO_2$ emissions by 24 per cent. Measures to reduce the carbon footprint include relying more on renewable energy (solar and wind power), optimising processes on the ground, building greener buildings that use less energy, optimising airport facilities and adding vehicles with alternative, e.g. electric, drives to their fleets. Germany's airports have set themselves ambitious targets for the future and aim to cut their $CO_2$ emissions by half by 2030. They plan to be completely carbon neutral by 2050.

- Better air traffic management can also reduce environmental damage. The SESAR (Single European Sky Air Traffic Management Research) programme, for example, is working on establishing a standardised European airspace. SESAR is managed by the SESAR Joint Undertaking (SJU), which believes that innovative, technological and operational solutions could save up to 500kg of fuel, or 1.6 tonnes of $CO_2$, per flight. This is equivalent to an overall reduction of 10 per cent per flight.

- A feasibility study of climate-optimised routes carried out by the German Aerospace Center in 2014 found that alternative routes over the North Atlantic could also significantly reduce the climate impact of non-carbon emissions, i.e. other greenhouse gases that are emitted during a flight. More direct flights from London to New York, for example, are up to 25 per cent less damaging to the climate, at an increased cost of only 0.5 per cent per passenger.

**Additional, logistical initiatives could help to reduce aviation's carbon emissions**

More efficient organisation of air traffic also offers opportunities to effectively reduce emissions and costs. But all parties must show willingness if global initiatives, in particular, are to have any real success. The complexity of coordinating such initiatives often puts the brakes on their implementation. Nevertheless, a great deal could be achieved in this way – combined with technological improvements – to make civil aviation more climate-friendly than it is today.

# 6 Summary

Flying still has a future. Civil aviation remains a growth market, as global economic links and the desire to travel are as strong as ever. Nonetheless, the aviation sector will have to face the challenges presented by regulation, climate policy and attitudes in society. Not only to meet the requirements of the Paris Agreement but also to ensure that their companies remain successful in the future. The aviation sector must tackle a range of challenges at the same time for this to be achieved. Multiple initiatives will need to be implemented successfully if global aviation overall is to make an adequate contribution to reducing $CO_2$ emissions:

- In the medium to long term, the most promising approach to reducing $CO_2$ emissions will be the use of sustainable aviation fuel –initially by blending biofuels and kerosene, and at some point in the future by using PtLs. The Finnish company Neste is a pioneer in the field of biofuels. German engineering companies such as Siemens and ThyssenKrupp could help to establish the infrastructure for PtL plants.

- Airlines can react to regulatory requirements by renewing their fleets and switching to more efficient engines. In this respect, the International Consolidated Airlines Group (IAG) is well positioned in comparison to its competitors. Currently, low-cost carriers such Ryanair and easyJet, which are burdened by higher $CO_2$ certificate prices and disadvantaged by new European taxes, are falling behind.

- In the medium term, the dream of electric flight appears most likely to be fulfilled on short-haul routes. This will require safer and more efficient batteries, and more research is also going into hybrid propulsion systems. The leading aircraft manufacturers, Boeing and Airbus, and engine manufacturers such as Rolls-Royce hope to reduce $CO_2$ emissions this way. Hybrid propulsion systems rather than fuel cells appear most likely to come into use first.

- In order to reduce global $CO_2$ emissions, airlines are once again relying on offsetting models. These projects not only improve the climate and reduce companies' carbon-related costs but will also help to restore the acceptability of air travel in society.

**Passivity is not an option for airlines**

As this paper has highlighted, the aviation sector is facing a number of major challenges. The solutions are neither simple nor one-dimensional. Affected companies will need to combine a number of different approaches if they are to respond appropriately to changes in the business and regulatory environment. Being passive is not an option. Only the airlines that take the right steps as soon as possible to equip their business for the future will survive in the market over the medium to long term. These airlines will retain their 'licence to fly' and profit from the ever-growing aviation market.

## Disclaimer

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