THE FUTURE OF AVIATION IN A WORLD OF SUSTAINABLE TRANSPORT

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CONTENTS

Air transport plays a vital role in economies. The number of flights increased by approximately 38% between 2010 and 2019[1] and is still expected to resume a strong long-term growth globally despite the COVID-19 crisis[2], albeit below 2019 levels for the years to come.

This can mainly be attributed to strong forecasted growth in developing countries[3], especially in middle class populations, driving the need and market for greater local and global connectivity within these regions.

In the past, air transport's practicality and the lack of realistic substitutes for medium and long-haul travel have made aviation the sector of choice for enabling connectivity. However, recent years have been marked by a blow to public perception of air transport, prompted by the environmental concerns regarding climate change. The notion of "Flygskam" - or flight shaming - emerged from Sweden in 2019 (where a 9% fall in domestic air passengers and a 4% drop overall was recorded in the same year) and spread across western Europe[4].

COVID-19 then plunged the aviation industry into an unprecedented crisis, with various governments stepping in to support manufacturers, airlines, airports, and ANSPs alike[5]. However, many are calling for aviation to use this period of reduced demand and enforced change to accelerate green initiatives, even to the extent of attaching conditions to support financing packages[6].

In this paper, we will lay out the issues that aviation is facing with regards to emissions, how these issues are changing mindsets amongst consumers and policy makers, trends in alternative modes of transport and their disruptive potential, the place of aviation in the global economy, and a way forward for businesses, governments, and regulators alike.

[1] ACI - World Airport Traffic Reports 2010 and 2019
[2] Lufthansa Consulting - Revamping passenger demand models for a post-COVID aviation world (2020)
[3] Economist Intelligence Unit - Long-term macroeconomic forecasts: Key trends to 2050 (2015)
[4] European Investment Bank - 2nd EIB Climate Survey (2020)
[5] FlightGlobal - ICAO welcomes government support for aviation sector (2020)
[6] Transport & Environment - Airline Bailout Tracker (2020)

AVIATION EMISSIONS AND CLIMATE CHANGE

The primary environmental impact of aviation stems from the heat, noise, ultra-fine particles, and gases emitted by aircraft engines, contributing to ecosystem and climate change. The Intergovernmental Panel on Climate Change (IPCC) considers that these emissions contribute to 4.9% of human-caused climate change.

While the effects of CO2 emissions on the climate have been recognised for the past decades, making them a priority target for mitigation efforts, impacts from non-CO2 emissions cannot be ignored. The European Aviation Safety Agency (EASA) argues in a recent report that non-CO2 climate impacts from aviation activities (such as contrails, NOx, soot produced by engines, etc.) are at least as important as those of CO2 emissions[7]

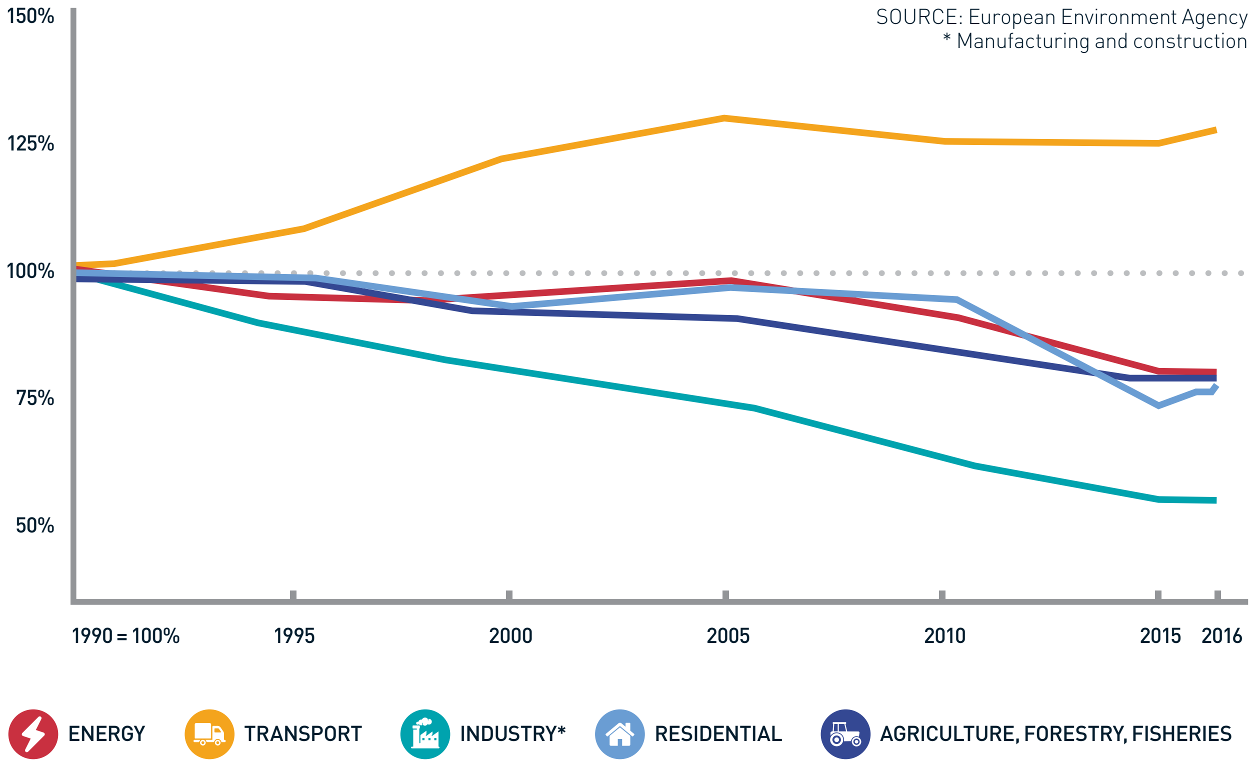
[7] EASA - Updated analysis of the non-CO2 climate impacts of aviation and potential policy measures pursuant to the EU Emissions Trading System Directive Article 30(4) (2020)
[8] European Environment Agency
[9] Reuters - Explainer: How the aviation industry's carbon offsetting scheme will work (2019)
[10] ICAO - Environmental Trends in Aviation to 2050 (2019)

Unlike CO2 impacts, which directly correlate to the amount of fuel burned, the complexity of measuring non-CO2 climate impacts - and the uncertainty regarding trade-offs between the various impacts - makes targeted action in this area more challenging.

Currently, direct CO2 and non-CO2 emissions from aviation are estimated to account for about 3% of the EU's total greenhouse gas emissions and 13% of all transport related emissions[8]. While these figures may not seem high, in an increasingly mobile world, global aviation emissions are approximately 70% higher than in 2005[9] due to rising demand. Furthermore, back in 2019 ICAO estimated that by the year 2050 CO2 emissions from international aviation could grow by 300%[10] beyond pre-COVID-19 levels.

Indeed, transport as a whole is one of the few industries which had not seen a reduction in total emissions over the past 30 years (prior to the COVID-19 crisis).

EVOLUTION OF CO2 EMISSIONS BY SECTOR (1990-2016)



As other sectors of the economy and means of transport are set to become even greener through electrification, aviation is increasingly becoming responsible for a larger portion of global climate change driven by aviation traffic growth and significant emission reductions in other industries.

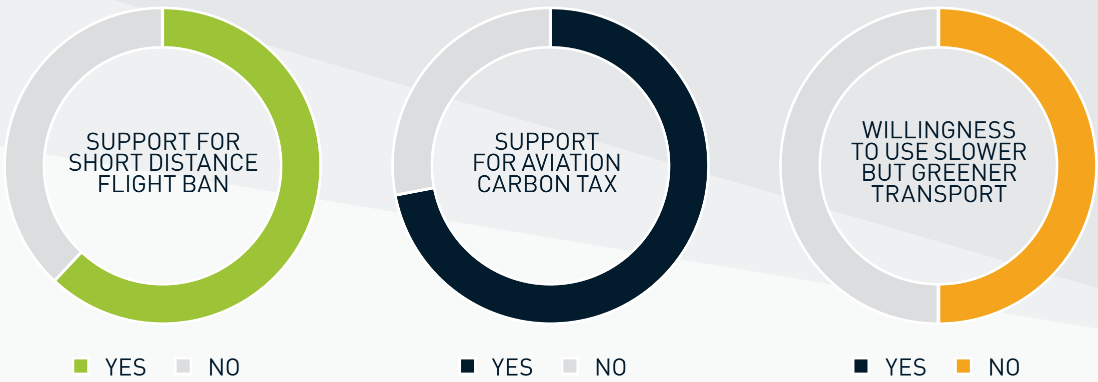
That said, aviation is also becoming greener. Engines are becoming more efficient, and aircraft more aerodynamic and lighter through advanced technology. However, the increase in demand has outstripped these improvements, meaning that the net output of emissions is increasing.

Unlike other industries, the physics behind modern day flight makes it difficult for aviation to immediately move away from fossil fuels without adding considerable limitations on aircraft performance.

Very much like road transport a few decades ago, cleaner alternatives to kerosene combustion engines are not viable solutions today; and while advancements are being made through ever more fuel efficient aircraft, sustainable aviation fuels, hydrogen powered engines, and hybrid propulsion, public pressure on policy makers to address environmental concerns is increasing.

EVOLVING MINDSETS AND POLICY

In October 2019, the European Investment Bank (EIB) surveyed 28 088 citizens of the then 28 EU member states (including the UK) on their likelihood to support a ban on short-distance flights to fight climate change. Results showed that 62% favoured a ban and an even greater majority of 72% said they would support a carbon tax on flights[11]. Complementing this, a survey carried out by OAG, a global travel data provider, on over 2000 travellers in January and February 2020 identified that one in two travellers would be willing to take a greener mode of transportation even if it took longer than the typical flight[12].



SOURCE: 2019-2020 EIB climate survey (2019)

These figures give an insight into how people are beginning to look at travel differently. They also show that more people want action taken than are willing to act. This paradox suggests that demand alone in the current world may not be a strong driver for change.

High-speed trains are being considered as a viable substitute to short haul flights more seriously than ever before. A survey from UBS Evidence Lab in four European countries and China suggested that leisure travellers would tolerate up to six hours on a train and that business travellers in Europe would accept up to four hours compared with a general consensus of two to three hours[13], motivated by city-centre departure and arrival points and relatively short waiting times.

Employers around the globe are starting to review their travel policies, driven by employees reconsidering the necessity of travel in a new era of video conferencing. Some of the most environmentally conscious employers are even starting to make it easier for staff to take greener leave by offering employees additional 'paid travel leave' should they choose to travel via train in order to compensate for the additional travel time required[14].

Governments and organisations are beginning to realise the extent to which aviation's emissions present a major threat to long term environmental targets - driven by air traffic growth predictions, the amplified effects of high-altitude emissions relative to those at ground level, and the lack of practical alternatives to kerosene powered engines in the short-term[15].

These trends are naturally contributing to increased pressure on governments and policy makers to tackle the impact of air transport on the environment. Such measures will certainly result in pressures on and changes to the operating environments of actors across the aviation value chain (aerospace manufacturers, airlines, ANSPs, and airports alike).

For example, some measures that governments and regulators could consider implementing could make flying less appealing by increasing environmental taxes on flying, taxing those individuals who fly most often, or even banning frequent flyer and loyalty programmes which have a legacy of incentivising passengers to stick to air travel, and even to travel on inefficient routes (consisting of layovers rather than direct flights). Sweden introduced such environmental taxes back in 2018 with France also following suit in 2020 and the Netherlands in 2021[16].

Governments are also looking to provide advantageous market conditions for less carbon intensive transport. This has already begun, for example, the German government has cut VAT on long-distance train travel from 19% to 7%, immediately and directly resulting in lower cost long-distance train travel for customers[17]. The French government has taken this a step further, by setting anti-competitive measures on rail-air short-haul domestic travel (whereby Air France, as a receiver of a state bail-out package, will have to drastically reduce domestic flights on routes where there is a rail alternative with a duration of less than 2.5 hours)[18] and insisted that a tenth of the EUR 15 billion support package provided to the aerospace industry be spent on speeding up the development of a carbon-neutral, hydrogen-powered plane by 2035[19].

Although these measures are ambitious, their effectiveness is questionable. The challenge with the French competitive measures is that other domestic carriers will likely take over many of Air France's dropped routes as rail is no more attractive to the paying customer than it was before the pandemic. And while hydrogen has significant potential to reduce the climate impact of aviation, the need for larger onboard tanks would necessitate costly and extensive aircraft redesigns along with supply-chain overhauls to become prevalent. The required investments are estimated to lead to an increase in airline operating costs of USD 5-10 per passenger[20]. However, this cost increase could be less consequential than potential carbon taxes on flight tickets.

In the longer run, the EU's new Green Deal is set to be a major driver for coordinated policy change at a European level, setting the scene for decarbonisation of the economy and laying out plans to ensure that transport prices reflect its impact on the environment and health. Naturally, all aspects of aviation are in the spotlight, including air traffic management as the statement paves the way for work to 'restart' on adopting the proposal on a truly Single European Sky in the view of achieving significant reductions in aviation emissions[21].

11 Reuters - Ban short-haul flights for climate? In EU poll 62% say yes (2019)
12 OAG - A greener world of travel: Why it still matters and how to get there (2020)
13 UBS Evidence Lab (survey of 1000 people)
14 BBC - Some firms give more time off to those who shun plane travel (2019)
15 Environmental Protection UK
16 The Economist – Flying into a Storm, The World in 2020 (2019)
17 The Guardian - Germany cuts fares for long-distance rail travel in response to climate crisis (2020)
18 FlightGlobal - French government sets green conditions for Air France bailout (2020)
19 Reuters - France bets on green plane in package to 'save' aerospace sector (2020)
20 Hydrogen-powered aviation. A fact-based study of hydrogen technology, economics, and climate impact by 2050 - Clean Sky 2 JU and Fuel Cells and Hydrogen 2 JU (2020)
21 European Commission - The European Green Deal (2019)

ALTERNATIVE FORMS OF TRANSPORT

Most keen travellers nevertheless know that giving up the habit of flying is not as easy as it may sound. Noble intentions struggle to compete against the time-efficient and usually cheaper model of air transport (depending on the point of origin and destination).

However, this social and political shift comes at the same time as major developments in alternative forms of transport.

On a European level, the size of high-speed rail networks is growing considerably. Given that the European high-speed rail network was blasted as an 'ineffective patchwork of poorly connected national lines' by the European Court of Auditors in 2018, institutions have doubled down on efforts, investments, and the creation of legal powers to ensure that countries make rapid progress towards completing a core network. In fact, UBS (a multinational investment bank) expects Spain, France, Germany, and Italy to add a total of 800 high-speed trains to the network by 2030 and for over EUR 100bn to be invested on an EU level. China is following suit with an expected CNY 800bn (EUR 103bn) to be spent on their domestic network over the same period[22].

In parallel, the European long-distance passenger-rail market is going through a phase of mass liberalisation (introduced by the EU railway packages), guaranteeing market access by reducing competitive and technical asymmetries among national networks. This regulatory overhaul will present incumbents and new entrants with the opportunity to open new routes between towns, cities, and countries and exploit potential that was previously untapped, consequently improving frequency and affordability on international routes. UBS expects this to boost the sector's market opportunity to EUR 11bn by 2022, almost double that estimated by the European rail industry body UNIFE.

Furthermore, innovations in the medium-distance travel segment which not so long ago seemed very farfetched, such as maglev and Hyperloop technology, are gradually materialising. Virgin Hyperloop One announced its ambitions for a service to be up and running by 2029 (with Indian lawmakers having given it the stamp of approval as a 'public infrastructure project'), while Central Japan Railways plans to link Tokyo with Nagoya (approximately 350 km) via maglev train by 2027. These solutions could deliver affordable ultra-high-speed mass transit systems which are significantly faster than high-speed trains, and greener than commercial jets when energy efficient during construction, run on clean electricity, frequent and near capacity, and enticing enough people away from air and road travel.

[22] UBS research - By Train or Plane?' The Traveller's Dilemma after Covid-19 and amid Climate Change Concerns (2020)
*Pre COVID-19 estimates

COMPETITION IN THE SHORT HAUL TRAVEL SEGMENT

Considering the above trends, the busiest European and global city air route pairs may look very different in the future. All of these city pairs are economically important domestic air routes, and many ideal target markets for high-speed ground transport.

TOP 10 EUROPE DOMESTIC ROUTES

ROUTE			SEATS
BCN-MAD	Barcelona	Madrid	3,650,780
ABD-SAW	Izmir	Istanbul Sabiha Gokcen	3,171,479
ABD-IST	Izmir	Istanbul Ataturk	3,041,975
FRA-TXL	Frankfurt	Berlin Tegel	3,040,364
LED-SVO	St Petersburgh	Moscow Sheremetyevo	2,999,008
AYT-SAW	Antalya	Istanbul Sabiha Gokcen	2,993,088
ORY-TLS	Paris Orly	Toulouse	2,908,372
OSL-TRD	Oslo	Trondheim	2,887,403
MUC-TXL	Munich	Berlin Tegel	2,832,560
BCN-PMI	Barcelona	Palma	2,798,280

TOP 10 GLOBAL DOMESTIC ROUTES

ROUTE			SEATS
CJU-GMP	Jeju	Seoul Gimpo	17,426,873
CTS-HND	Sappore New Chitose	Tokyo Haneda	12,498,468
FUK-HND	Fukuoka	Tokyo Haneda	11,400,018
HAN-SGN	Hanoi	Ho Chi Minh	10,253,530
MEL-SYD	Melbourne	Sydney	9,958,500
BOM-DEL	Mumbai	Delhi	8,230,822
PEK-SHA	Beijing Capital	Shanghai Hongqiao	8,117,461
JED-RUH	Jeddah	Riyadh	8,018,205
HND-OKA	Tokyo Haneda	Okinawa	7,704,098
HND-ITM	Tokyo Haneda	Osaka Itami	7,248,300

SOURCE: OAG - OAG Busiest Routes 2019

In Europe, major high-speed rail projects have had highly disruptive effects on air transport routes.

Eurostar, which opened over 25 years ago, now connects the centre of London with those of Paris in 2h16, Brussels in 1h53, and Amsterdam in 3h52. Back in 1996, air transport capacity between London and Paris was estimated at 4.8 million seats[23]. In 2019, that figure was estimated at 2.7 million seats, representing a 44% reduction over a period where global air passenger numbers grew by over 200%[24].

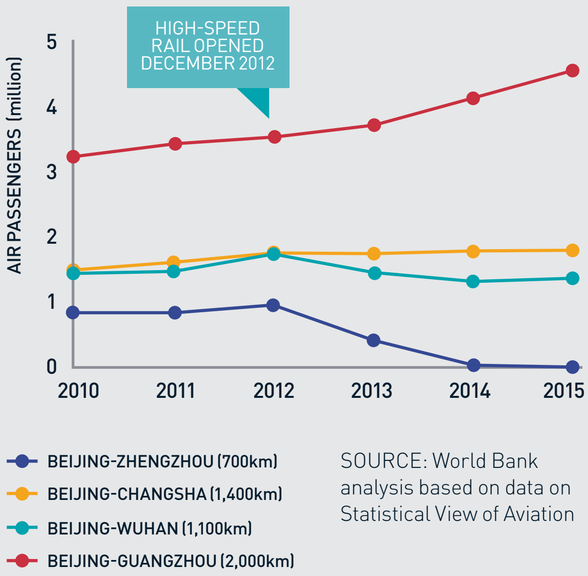
China, which has one of the largest middle-classes in the world and has been investing heavily in high-speed rail (very much in the way Europe and others are doing now), has seen similar competitive trends.

Since the opening of the first line in 2008, total rail passenger volume has grown exponentially. At 600 billion passenger-kilometres (pkm) in 2019, China's high-speed rail network produced more than four times as many pkm as those in Europe or Japan. As a result, some short-haul services have been completely withdrawn following the opening of high-speed rail lines, and others have considerably reduced services.

For example, while high-speed rail had no discernible impact on the air route between Beijing and Guangzhou (2000 km), demand for Beijing–Changsha flights (1400 km) only grew at a much slower rate, air passenger numbers between Beijing and Wuhan (1,100 km) dropped, and the reduction between Beijing and Zhengzhou (about 700 km) was so great that the air service was very substantially reduced.[25]

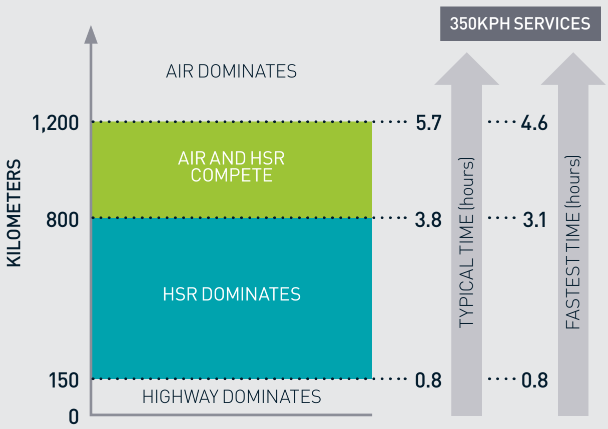
To the Chinese domestic traveller, the proximity of stations to city centres, reliability, freq uency, affordability, and comfort of high-speed rail are strong selling points for most middle-distance trips.

EFFECT OF BEIJING-GANGZHOU HIGH-SPEED RAIL ON AIR TRAVEL



SOURCE: World Bank analysis based on data on Statistical View of Aviation

COMPETITIVENESS OF HIGH-SPEED RAIL



SOURCE: World Bank - China's High-Speed Rail Development (2019)

Note: The competitive ranges of the three models are indicative. The air and high-speed rail (HSR) competitiveness was studied with a sample of 300-350kph lines. with a different price and speed assumptions of 200-250kph lines, the dominance range will be slightly different.

[23] OAG - High Speed Rail Vs Air: Eurostar at 25, The Story So Far (2019)
[24] World Bank - Air transport, passengers carried
[25] World Bank - China's High-Speed Rail Development (2019)

Such developments are making airlines and airports rethink their operating models and are leading to the appearance of "rail-air" type alliances in key regions, by which passengers can choose to book rail connections to/from certain cities/airports (as they would a connecting flight with the airline or codeshare partners).

AIRLINE	TRAIN COMPANY	AIRPORT
Lufthansa American Airlines Emirates	Deutsche Bahn	**Frankfurt Airport**
Austrian Airlines	OBB	**Vienna International Airport**
Swiss International Airlines	SBB	**Zurich Airport**
Air France	SNCF	**Paris-Charles de Gaulle Airport**
KLM	Thalys	**Amsterdan-Schiphol Airport**
American Airlines	Thalys	**Paris-Charles de Gaulle Airport**
United Airlines	Amtrak	**Newark Liberty International Airport**

Not exhaustive

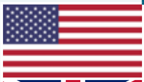
SOURCE: Desk Research

This is likely to become an increasingly common trend around the developed world, as airlines adapt to maintain and expand levels of connectivity, while restrictions and anti-competitive measures come into place on short haul flights, as they have in France. However, it is important to remember that France is considered to have one of the most developed networks in the world and Paris Charles de Gaulle Airport (Air France's main hub) has high-speed rail links to major metropolitan areas (including Brussels, Marseille, Lyon, Lille, Montpellier, Nantes…).

In reality, the world that we currently live in and its infrastructure has evolved in such a way that the direct economic benefits (and net present value (NPV)) of air transport investments are generally considered to be much higher than those of high-speed rail travel. The following section explores this more in detail.

THE HIGH COSTS OF HIGH SPEED

High-speed transport projects, while boasting many economic and social benefits, come at a cost correlated to their size (and hence, to the transport distance and network). This cost is naturally due to the need for physical infrastructure along the route and physical restrictions of geography and urban areas. Furthermore, most projects today need to be started from scratch, which exposes governments and financers to lengthy returns on investments, considerable risks, and high costs.

	TECHNOLOGY	PROJECT	LINE LENGTH	COST PER KM
	RAIL	California High-Speed Rail	600 km	USD 132m
	RAIL	High Speed 2	500 km	USD 233m
	MAGLEV	Shanghai Transrapid	30 km	USD 58m
	MAGLEV	Chuo Shinkansen	350 km	USD 236m

SOURCE: Desk Research

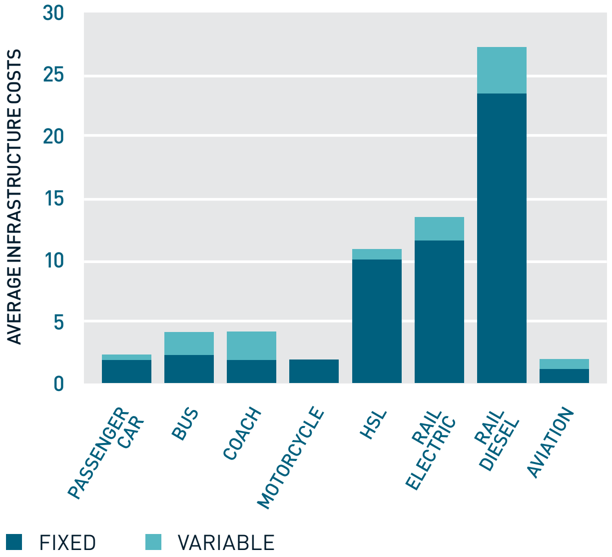
The cost of California's high-speed rail project (600 km) for instance grew to USD 79bn in 2019, a development that renewed calls for it to end. Similarly, the UK's controversial HS2 (high-speed 2) project (500km), initially budgeted in 2012 at GBP 32.7bn was officially re-estimated in 2019 to cost GBP 88bn (USD 117bn in 2019 values). While maglev also claims economical solutions compared to rail , Shanghai's relatively short maglev line (30km) cost approximately RNB 10bn (USD 1.7bn in 2019 values) to build, and Japan's 350 km one will cost around JPY 9tn (USD 83bn in 2019 values).

Such variations in costs amongst different project is attributable to many factors including the extent of geographical and urban obstructions, distribution of population, integration with existing infrastructure, workforce skills, and more. These capital costs will also influence average passenger fares to varying extents depending on demand, costs of capital, and ticketing models.

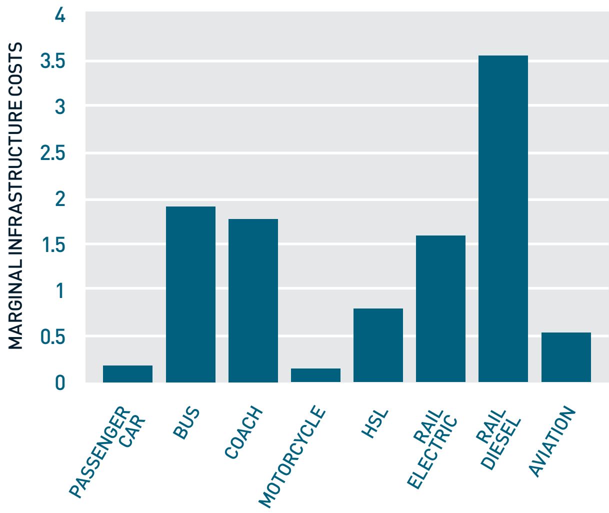
The price tags of the above infrastructures often dwarf those of aviation infrastructure projects, such as Beijing's latest mega-airport, officially costing CNY 80bn (USD 11bn in 2019 values)[26]. Analysis for the European Commission showed that average and marginal infrastructure costs of passenger transport in the EU28 are significantly higher for rail transport than for aviation[27].

[26] Financial Times - My first flight to Beijing's spectacular 'starfish' airport (2019)
[27] European Commission - Sustainable Transport Infrastructure Charging and Internalisation of Transport Externalities: Main Findings (2019)
[28] OECD International Transport Forum - The Economics of Investment in High-Speed Rail (2014)

AVERAGE INFRASTRUCTURE COSTS IN 2016 FOR PASSENGER MODES IN THE EU28 (€-cent/pkm, PPS adjusted)



MARGINAL INFRASTRUCTURE COSTS IN 2016 FOR PASSENGER MODES IN THE EU28 (€-cent/pkm, PPS adjusted)



For aviation, the average infrastructure costs are estimated on data for the 33 selected EU airports.
SOURCE: EC - Sustainable Transport Infrastructure Charging and Internalisation of Transport Externalities: Main Findings (2019)

Furthermore, the Organisation for Economic Co-operation and Development (OECD) identified the different objectives of various high-speed rail schemes in a roundtable report on the economics of investment in high-speed rail[28] as presented below. Interestingly, aviation infrastructure developments often claim the same benefits for all the objectives listed below except for environment, which has only recently become an objective of high-speed rail.

So while high speed land based transport is a proven competitor for aviation on short-haul routes, the economic characteristics and overall negative net present value (NPV) mean that such transport networks would struggle to provide a compelling business case (and hence be a suitable substitute for air transport on long/medium-haul routes) in countries/regions where geography, public budgets, or sociodemographic factors may make investment in road or air transport networks much more attractive.

	FRANCE	JAPAN	CHINA	ITALY	UK	CHINESE TAIPEI	SPAIN
SPEED	✓	✓	✓	✓	✓	✓	✓
CAPACITY	✓	✓	✓	✓	✓ (HS2)	✓	
RELIABILITY				✓	✓ (HS1)		
ECONOMIC DEVELOPMENT			✓		✓	✓	
SUPPLY INDUSTRY	✓	✓	✓				✓
PRESTIGE	✓		✓	✓			✓
POLITICAL INTEGRATION			✓				✓
ENVIRONMENT					✓ (HS1)		

SOURCE: OECD International Transport Forum - The Economics of Investment in High-Speed Rail (2014)

THE ECONOMIC ADVANTAGE

Air transport requires significant infrastructure at points of arrival and departure (airports) and to a certain extent along the route (air navigation services). Nevertheless, it can currently offer considerably larger economies of scale and greater flexibility at less of a financial and commercial risk than high-speed rail. Furthermore, airports can ensure links to virtually any other airport in the world, not simply those along a set route. For this reason, air transport has always been considered the most efficient way of linking most cities, regions, and countries.

Thanks to these factors, globalisation, and technological advancements air transport has historically doubled in size every fifteen years and grown faster than most other industries, closely tracking the trend of global economic growth.

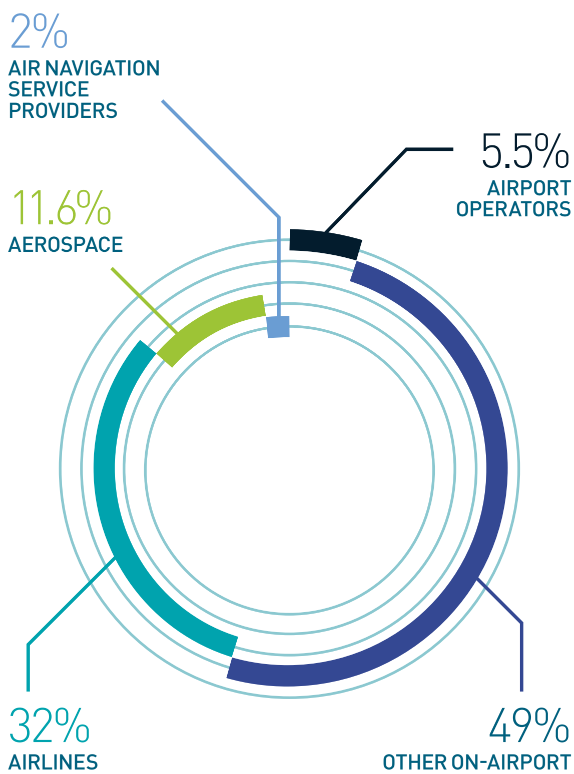
In a pandemic free world, the aviation industry is a powerhouse of economic activity, directly creating jobs at aerospace manufacturers, airlines, airports, and air navigation service providers. Aviation activities directly generated an estimated 11.3 million jobs and added approximately USD 961.3 billion to global GDP annually.

This economic importance of aviation however goes even further than direct impacts, demonstrating the breadth of air transport's economic reach. These include the jobs and output generated by suppliers to the air transport industry, by the spending of wages of those directly or indirectly employed in the sector, by the business enabled by air travel and cargo, and by the general effect of globalisation relying on fast and cost-efficient connectivity.

Given this breadth and the complexity of the world we live in, it is difficult to determine the actual impact of all the economic, social, or political benefits of air transport.

However, estimates by Oxford Economics of the economic value generated by aviation's direct, indirect, induced, and leveraged[29] pre-pandemic activity amounted to 87.7 million jobs and USD 3.5 trillion in GDP annually.[30]

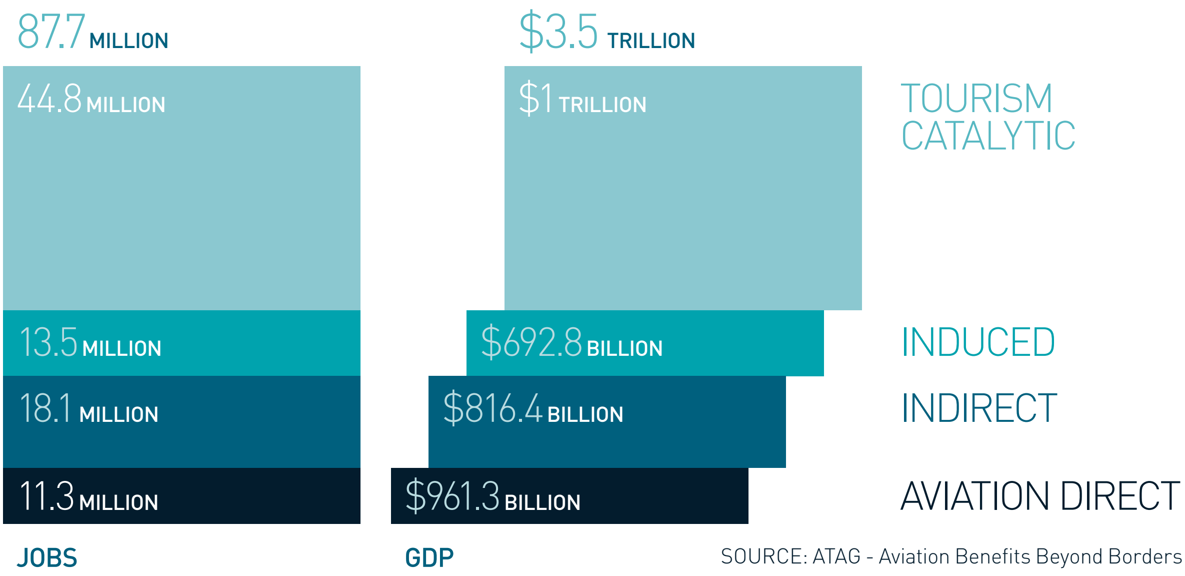
DIRECT EMPLOYMENT IN AIR TRANSPORT BY SEGMENT



SOURCE: ATAG - Aviation Benefits Beyond Borders (2020)

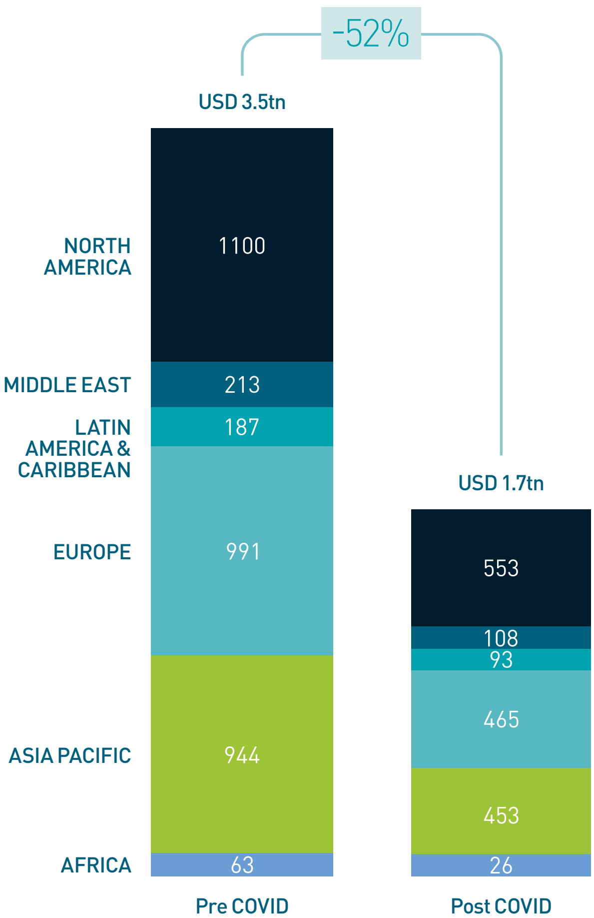
[29] I.e: Spending by the 57% of tourists which travel via the air.
[30] ATAG - Aviation Benefits Beyond Borders (2020)

AVIATION'S GLOBAL EMPLOYMENT AND GDP IMPACT



SOURCE: ATAG - Aviation Benefits Beyond Borders (2020)

ECONOMIC ACTIVITY SUPPORTED BY AVIATION



SOURCE: ATAG - Aviation Benefits Beyond Borders (2020)

The COVID-19 crisis has given us an insight into what a world without air transport looks like, and how drastically industry profits can deteriorate with variations in demand. Companies began to struggle financially one after the other. Fleet orders were cancelled, thousands were laid off, and bankruptcies were filed, creating a knock-on effect across the global economy. The tourism industry (which represented a considerable portion of GDP for many countries across the globe) entered immediate decline[31]. Supply chains seized up as passenger flight cancellations (which carried more than half of air cargo prior to COVID-19) made it more difficult and costly to move fresh food, mail, and high value goods around the world[32].

According to Oxford Economics, the economic activity and jobs supported by aviation dropped by more than 50% to USD 1.7 trillion and 46 million jobs respectively as a result of the pandemic.

[31] The Guardian - Covid-19 throws Europe's tourism industry into chaos (2020)
[32] Wall Street Journal - You've Got Mail...Finally: The Pandemic Is Jamming Up the World's Post (2020)

The crisis highlighted how essential aviation is in our global village. As travel restrictions around the world wiped out even the longest standing airline routes, governments and aviation worked together to quickly repatriate citizens, efficiently ship medical equipment, and even reallocate production and human resources to healthcare.

Very quickly, much of the developed world announced support packages for the aviation industry, providing equity injections, loans, and other various arrangements to manufacturers, airlines and ANSPs alike to keep the industry afloat. Such support comes as a reminder of the reality that very few governments will be willing to turn their backs on aviation or to take drastic measures to reverse the growth of air transport.

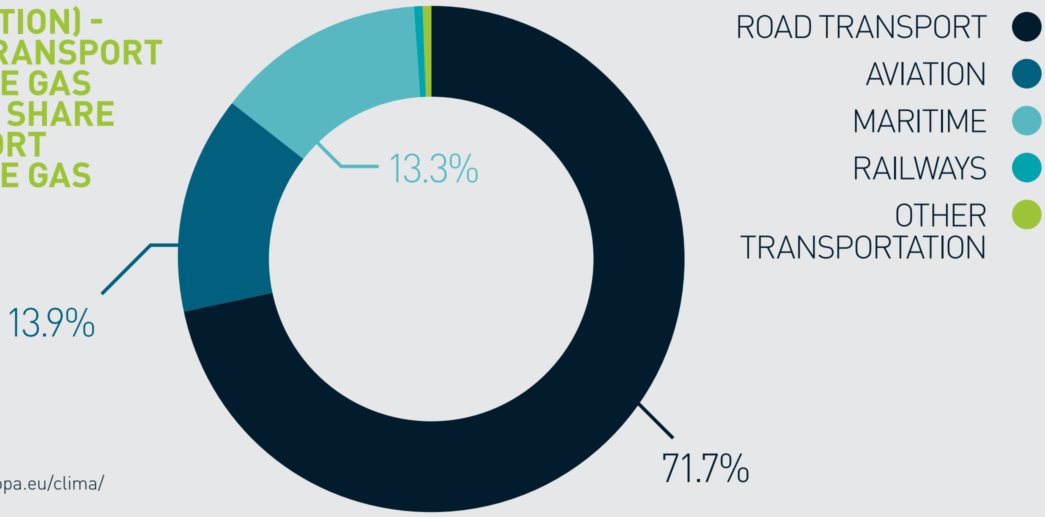
THE HARSH REALITY OF EMISSIONS AND THEIR MITIGATION

Despite aircraft being considered the highest emitting mode of transport per passenger km, road transportation accounts for over 70% of total transport emissions in the EU whereas civil aviation makes up 13.4% in comparison. Further evidence of this also came to light during the height of the COVID-19 pandemic. Daily global emissions of CO2 fell by 17% at the peak of the shutdown, mainly driven by the 43% decline in surface transport emissions (the same figure as that from industry and power generation combined). However, aviation only accounted for 10% of the decrease during the pandemic, despite the slowdown dominating the headlines[33].

Furthermore, road transport is generally considered to be more substitutable, and currently offers more mature energy alternatives than air transport.

For these reasons, aviation has historically been subject to less drastic taxation than the automotive industry, which emerges as a more economically efficient and impactful target for eco-taxation.

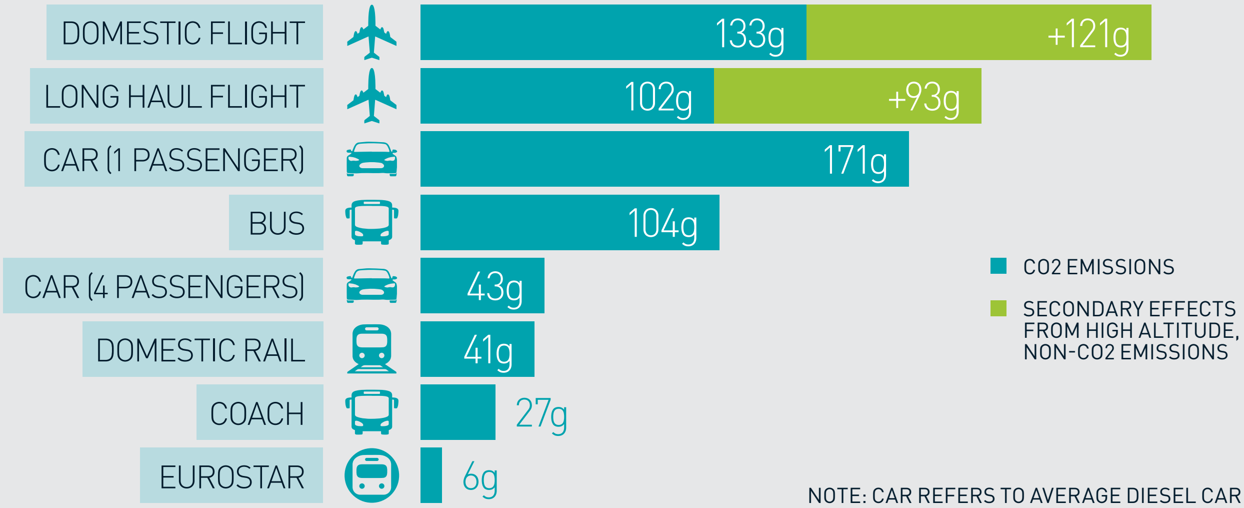
EU (CONVENTION) - SHARE OF TRANSPORT GREENHOUSE GAS EMISSIONS - SHARE OF TRANSPORT GREENHOUSE GAS EMISSIONS



SOURCE: https://ec.europa.eu/clima/policies/transport_en

[33] Le Quéré, C., Jackson, R.B., Jones, M.W. et al. - Temporary reduction in daily global CO2 emissions during the COVID-19 forced confinement. Nat. Clim. Chang. 10, 647–653 (2020)

EMISSIONS FROM DIFFERENT MODES OF TRANSPORT
EMISSIONS PER PASSENGER PER KM TRAVELLED



NOTE: CAR REFERS TO AVERAGE DIESEL CAR

SOURCE: **https://www.bbc.co.uk/news/science-environment-49349566**

The most common approach to date for tackling aviation emissions has been through offsetting schemes, which are a major part of much of the industry's "net zero" commitments and the Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA).

ICAO's CORSIA is a first of its kind as a global industry response to climate change. The aim of the scheme is to cap air transport CO2 emissions at 2019 levels through offsetting, mitigating the environmental impact of flying, even as passenger traffic is forecast to grow.

Airlines will have to purchase emissions reduction offsets from other sectors to compensate for any increase in their own emissions (or alternatively, use specific lower carbon fuels). Buying an offset essentially means buying a credit that has been verified as having reduced emissions elsewhere. Once airlines have bought this offset, they can use it to "cancel" their own emissions, removing the offset from "circulation".

CORSIA hence acts as a soft measure, mitigating an estimated 2.5 billion tonnes of CO2 between 2021 and 2035, and stabilising net CO2 emissions.

The scheme, however, has attracted considerable criticism as an offsetting scheme. Similar schemes in the past have been branded by some as "greenwashes"[34] as they essentially allow polluters to purchase offsets, rather than reducing their actual emissions[35].

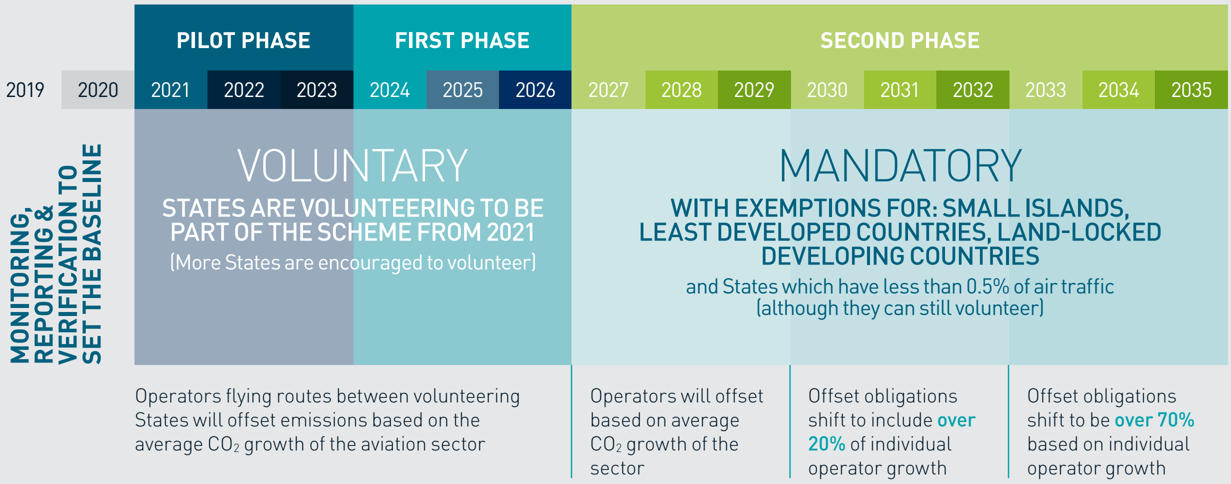
Nevertheless, offsetting may be well suited for the very human paradox mentioned earlier, where people seem keener for mitigation actions to be taken on aviation than they are to change their flying habits.

The underlying concern is that CORSIA offsetting is based on the Kyoto protocol Clean Development Mechanism (CDM), whereas it was found by a European Commission study that 85% of the offset projects used under the CDM either overestimated their impact or failed to reduce emissions. Furthermore, in situations such as the COVID-19 crisis, the emissions offsetting scheme will not take 2020 into account when calculating how much airlines must pay to neutralise their CO2 output. CORSIA's original rules use 2019-2020 as the reference point, which would in theory drag down the offset ceiling, making the cost of neutralising emissions higher.

Many argue that this tweaking of the baseline defeats the purpose of the three-year-long pilot scheme, as emissions growth is unlikely to climb back above 2019's levels and CO2 emissions will hence not be offset[36].

[34] Financial Times - Airlines face long-haul to carbon-free flying, 24 November (2019)
[35] Euractiv - Airlines granted huge emissions reprieve by UN compromise (2020)
[36] Aviation Benefits Beyond Borders - Who volunteers for CORSIA (2020)

CORSIA is currently a voluntary scheme until 2027, and remains voluntary for Least Developed Countries, Small Island Developing States and Landlocked Developing Countries from then onwards (and only emissions from international flights between volunteering countries are currently required to be offset).

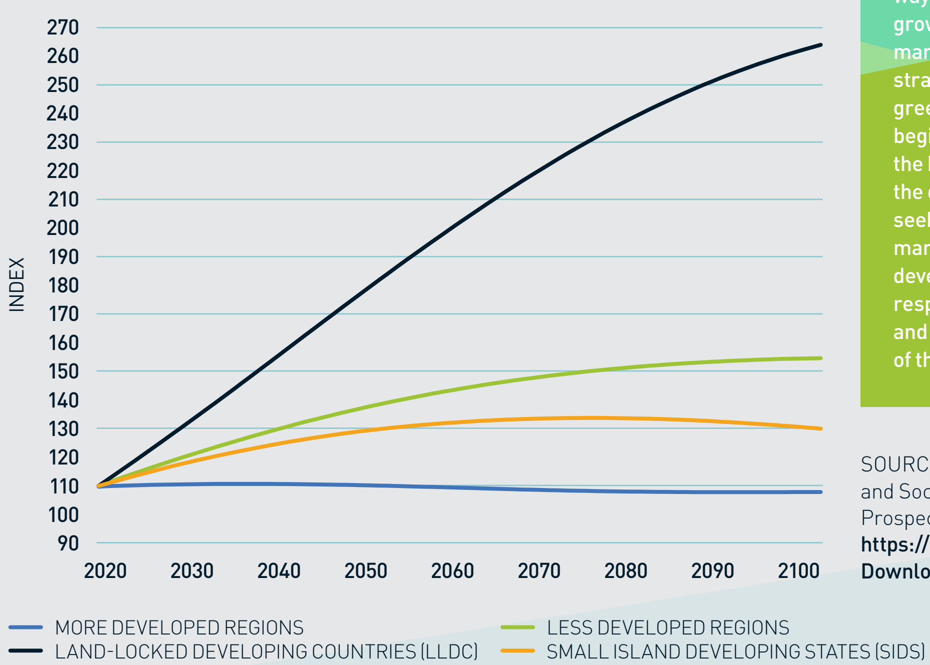


SOURCE: Aviation Benefits Beyond Borders - CORSIA explained (2020)

While as of today, the 88 states that will take part in CORSIA represent 77% of international aviation activity, much of the traffic growth will likely remain out of the scheme's scope as a result of strong middle and urban class growth in Africa, Asia, and Latin America, hence fuelling demand for domestic and international air transport links in these regions.

This foreseen growth in aviation will naturally come with consequent effects on global emissions, especially considering that low capital availability and sector regulation in the mentioned regions could lead to prevailing fleets of older, less efficient aircraft.

INDEXED POPULATION GROWTH (BY U.N. DEVELOPMENT GROUPS)



While offsetting schemes are a way to maintain a greener traffic growth in the short term, financial margins could start to come under strain in the developed world as green policies and investment begin to disrupt the market from the bottom up. Meanwhile, much of the developing world will naturally seek to establish favourable market conditions for air transport development, to the profit of their respective transport networks and economies, but at the expense of the environment.

SOURCE: UN Department of Economic and Social Affairs - World Population Prospects (2019), Medium fertility variant: **https://population.un.org/wpp/Download/Standard/Population/**

SECURING THE FUTURE OF AVIATION

Today's sustainability concerns are more than a passing trend. They are here to stay for the long term. Aviation now needs to work collectively to deliver sustainability across the value chain.

COMPARISON OF NEW TECHNOLOGY AND SUSTAINABLE AVIATION FUELS AND NEW TECHNOLOGIES

<table>
<tr><th>COMPARISON vs. KEROSENE</th><th>BIOFUELS</th><th>SYNFUELS</th><th>BATTERY-ELECTRIC</th><th>HYDROGEN</th></tr>
<tr><td>COMMUTER
< 19 PAX</td><td rowspan="5">NO LIMITATION OF RANGE</td><td rowspan="5">NO LIMITATION OF RANGE</td><td rowspan="3">MAXIMUM RANGES FROM 500-1000km DUE TO LOWER BATTERY DENSITY</td><td rowspan="3">NO LIMITATION OF RANGE</td></tr>
<tr><td>REGIONAL
20-80 PAX</td></tr>
<tr><td>SHORT-RANGE
81-165 PAX</td></tr>
<tr><td>MEDIUM-RANGE
166-250 PAX</td><td rowspan="2">NOT APPLICABLE</td><td rowspan="2">REVOLUTIONARY AIRCRAFT DESIGNS AS EFFICIENT OPTION FOR RANGES ABOVE 10,000km</td></tr>
<tr><td>LONG-RANGE
> 250 PAX</td></tr>
<tr><td>MAIN ADVANTAGE</td><td>Drop-in fuel - no change to aircraft or infrastructure</td><td>Drop-in fuel - no change to aircraft or infrastructure</td><td>No climate impact in flight</td><td>High reduction potential of climate impact</td></tr>
<tr><td>MAIN DISADVANTAGE</td><td>Limited reduction of non-CO2 effects</td><td>Limited reduction of non-CO2 effects</td><td>Change to infrastructure due to fast charging or battery exchange systems</td><td>Change to infrastructure</td></tr>
</table>

SOURCE: Hydrogen-powered aviation. A fact-based study of hydrogen technology,economics, and climate impact by 2050 - Clean Sky 2 JU and Fuel Cells and Hydrogen 2 JU, 2020

Technology breakthroughs will be the major drivers for environmental efficiency in the long term. For decades, common consensus has been that no real alternative to kerosene exists, but now the idea that alternative green energy sources could provide novel propulsion methods is materialising.

Sustainable aviation fuels and biofuels have recently emerged as a slightly cleaner complement to fossil fuels. Similarly, electric propulsion has been an exciting development thanks to exponential improvements in battery technology and its zero-emission model. However, sustainable fuel blends are still not as widely available as traditional ones, have limited effects on actual CO2 emissions, and battery powered aircraft are still too limited in range due to power to weight output and energy density.

Hydrogen is hence prevailing as the most promising long-term solution to zero-emissions aircraft, despite the previously mentioned hurdles that the technology faces. Airbus engineers believe that hydrogen could fuel aircraft through combustion in modified conventional gas-turbine engines, hydrogen fuel cells (through the conversion of energy from molecules into electrical energy), or synthetic fuels (through hydrogen produced via renewable electricity that is blended with fossil fuels).

However, despite the enthusiasm around hydrogen and its high potential as a substitute to kerosene, the technology as of today still has many challenges and limitations to overcome.

It is important to note that the solutions explored above are not sustainable by default. They will not necessarily help achieve emissions reduction unless implemented with globally-applied science-based measures and constraints.

In the meantime, by seeking to reduce transport emissions and achieve climate targets without sacrificing regional connectivity, developed economies will continue investing in low emissions ground-based substitutes (such as high-speed rail).

Over the next decades, significant intervention in the developed world will increase the relative NPV and affordability of high-speed rail. This will consequently lead to a shift in demand, and considerably reduce air transport market shares on key short and medium haul routes. However, the inherent cost, uncertain externalities, and complexity of such high-speed infrastructure will make it an unlikely investment for many of the newly developing economies.

The shift in growth to regions such as Africa or South-Asia will fuel a demand for short, medium, and long-haul transport links in emerging countries. The focus of their governments will be on cost-efficient and scalable infrastructure that delivers high economic value and risks providing little or no consideration for environmental externalities. These economic needs, along with difficult climates and terrain in key growth regions, will further boost the growth potential of aviation in these markets.

So, while low emissions propulsion technology has high potential to cut aviation emissions in the long run, the short to medium term development of high-speed ground transport will be an attractive path to cut transport emissions in the most wealthy countries. However, the rise of new growth epicentres in emerging regions will lead to equally strong air traffic and emissions growth, unregulated from an environmental perspective.

Uncoordinated and local approaches that hinder air transport will have a limited impact on emissions globally, and risk destabilising other industries and economies (including tourism and sectors reliant on air cargo) in doing so. Governments, regulators, organisations, and stakeholders of the aviation value chain need to work collaboratively and in parallel on achieving immediate and long term emissions reductions if aviation and its economic ecosystem are to prosper.

STRATEGIC RESPONSES - AVIATION ORGANISATIONS

In the short term, the focus for aviation organisations will continue to be on achieving operational excellence and tackling inefficiencies to mitigate current levels of emissions. This might include:

- Leveraging in house and external datasets and implementing digital solutions to streamline environmental efficiency and operational performance monitoring. Airports and air navigation service providers around the world are beginning to do so through live dashboards and digital twin technology[37].
- Reviewing and identifying inefficient operational practices to rethink and redesign processes based on environmental cost benefit analyses (environmental CBAs). Such CBA methods are already widespread in the public sector and promoted by the OECD as a rational and holistic decision-making tool[38].
- Setting ambitious and impactful goals and working collaboratively with operational stakeholders to streamline efficiency. Heathrow is a prime example of an aviation organisation which plans to use bold goal setting in the carrying out of its 'Heathrow 2.0' sustainability strategy[39].
- Seeking to obtain various independent eco-certifications across the organisation in order to maintain an audited standard of sustainability. For instance, Airports Council International (ACI) 'Airport Carbon Accreditation' scheme or the International Air Transport Association (IATA) Environmental Assessment (IEnvA) program are examples of certifications tailored to the air transport industry.

In the longer run, organisations public and private alike will need to redefine their priorities and strategies:

- Defining a sustainability vision and strategy and rethinking a compelling growth strategy that is complementary to the former. International Airlines Group (IAG) has taken a step in the right direction with their 'Flightpath net zero' strategy.
- Planning for multiple regulatory and market scenarios, futureproofing business models accordingly. Organisations around the globe already do so, but it is ever more important to take environmental trends into account. Easyjet[40] and JetBlue[41] among others are examples of such planners, citing future environmental regulation and reputational damage as key risks in their annual reporting.
- Reassessing merger and acquisition (M&A) options, and strategic partnerships vertically with innovative solution providers and horizontally with comparative industries to drive change and boost resilience. Aviation has already started working with start-ups through acquisitions or incubation/acceleration programmes such as the 'Airport Innovation Accelerator' in the United States, ADP Group's 'Airport Startup Day', IAG's 'Hangar 51' programme, or Easyjet's collaboration with 'Founders Factory'.
- Understanding and adapting to investor Environmental, Social and Governance (ESG) trends and goals to maintain capital and debt raising capabilities. Earlier in 2020 JetBlue Airways relied on strong ESG credentials to secure a sustainability-linked loan, a world first for an airline set up by BNP-Paribas, a French bank .

[37] International Airport Review - Improving airport decision making with the Digital Twin concept (2019)
[38] OECD - Cost-Benefit Analysis and the Environment: Further Developments and Policy Use (2018)
[39] Heathrow Airport Limited - Heathrow 2.0 2017 Sustainability Progress Summary (2018)
[40] Easyjet plc - Annual Report and Accounts 2020, Strategic Report (2020)
[41] JetBlue Airways - 2018 Sustainability Accounting Standards Board Report (2018)

STRATEGIC RESPONSES - GOVERNMENTS, INSTITUTIONS, AND REGULATORS

Governments and public institutions will play an equally important role in the orchestration of a sustainable industry. They will need to employ novel mechanisms to ensure that longer-term environmental interests are achieved, without compromising competitive and economic benefits. These might include:

- Fostering innovation through targeted tax vehicles, investor incentives, legal frameworks, grants, and backed loan facilities to accelerate the development of green technologies through research and development (R&D) and entrepreneurship.
- Accelerating the production and adoption of mature sustainable fuels and propulsion technologies through public policy and infrastructure investment to enhance their scalability.
- Implementing CORSIA in the voluntary phase to boost demand for sustainable fuels and set a precedent for international coordination.
- Ensuring that approaches are coordinated and harmonised internationally to prevent the appearance of unbalanced market conditions amongst countries.
- Publishing and maintaining widely available, dynamic, and targeted sustainability data dashboards to ensure transparency and standardised reporting. Many airports are experimenting this with 'Airline League Tables'[42] for public noise performance monitoring, and Eurocontrol publishes a set of environmental indicators for European ANS monthly[43].
- Setting up smart performance incentive schemes across the aviation industry that are strong enough to drive industry-wide change in the context of a green recovery. The air traffic management industry in Europe is already subject to similar mechanisms through the performance and charging scheme[44].
- Creating cross-industrial platforms and expert panels to drive thought leadership, innovation, and cooperation among the greatest minds in transport. The UK's 'JetZeroCouncil' is an example of such a partnership between industry and government to support the aim of achieving zero-emission flight by 2050.
- Considering the wider externalities of transport infrastructure and targeting investments accordingly, with the aim of creating an integrated and balanced transport network from an economic and environmental perspective.

As aviation emerges from the unprecedented crisis brought on by COVID-19, there is a clear opportunity to accelerate green initiatives. The industry has been making green strides in the domain of environmental efficiency and policy makers are now placing sustainable development at the top of their agendas. But to reach emissions targets and ensure aviation develops into a green industry, long and short-term decarbonisation efforts must be stepped up to the next level.

Acting now is crucial. As we work collaboratively towards a strong recovery, green solutions must be implemented at all levels to secure the future of aviation in a world of sustainable transport.

[42] Example: Heathrow Airport Fly Quiet and Green
[43] https://ansperformance.eu/efficiency/
[44] Steer/Egis - Further development in air traffic management in the area of performance incentives (2017)

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