Airline initiatives to reduce climate impact

WAYS TO ACCELERATE ACTION

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We would like to acknowledge the University of Surrey and their engagement of Prof Maria Jesus Bonilla Priego to extract relevant information form CDP reports, and also the Griffith Institute for Tourism for their general support of this report.

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EXECUTIVE SUMMARY

Airlines are facing mounting pressure from governments, the public and media to reduce their fast-growing CO_2 emissions. Scientists have calculated that the 'carbon budget' that remains to stay safely within 1.5 degrees Celsius warming will be depleted in 8 years and 2 months (from November 2019), assuming current levels of emissions. Whilst airlines currently only represent 2-4% of emissions, their share will increase to well over 20% in 2050 should aviation continue on its current growth path.

Demand for air travel continues to be strong; however, there are signs that the sentiment towards flying is changing. Ethical questions are being raised concerning air travel, including around equality, and an increasing number of organisations are setting carbon reduction targets for employee air travel. At the same time, governments are looking at taxing aircraft emissions, as one way to meet national obligations and contribute to international reduction goals. Internalising the cost of carbon will lead to increasing airfares and slowing demand for travel. This is opposite to past trends that saw fares become cheaper over time encouraging more people to travel.

Many airlines are aware of these challenges and are investing substantially into carbon reduction programs. This White Paper presents macro trends in the aviation industry around carbon emissions, followed by a more detailed analysis of initiatives reported by leading airlines. More specifically, the largest 58 airlines that make up 70% of total available seat kilometres were assessed. Particularly innovative approaches are highlighted, and where possible materiality is assessed. The paper draws on information that is publicly reported by airlines through their Sustainability Reports, websites or other public disclosures.

An analysis of airline reports shows that to date the industry fails to report carbon around an agreed set of measures, in particular, when benchmarking efficiency. Reverting to CO_2 per available seat kilometre as one common metric highlights that most airlines were able to demonstrate improvements in carbon efficiency, but essentially all of them increased their absolute emissions between 2017 and 2018. Only 35 out of the top 58 airlines provided information on emissions, highlighting the need for much improved disclosure and reporting in the industry. The collective improvement in efficiency of those 35 airlines was about 1% in 2018 compared to 2017.

Reporting and target setting is an established practice to enable successful decarbonisation. Only 16 airlines specified targets other than the general IATA industry targets. In addition, eight airlines used an internal price on carbon to incentivise change and investment towards lower-carbon alternatives. In total, it was found that airline initiatives to save emissions fall into 22 different categories of action. These range from aircraft efficiency measures to improving flight operations. They also include leadership and partnership initiatives. Some airlines also report on their on-the-ground improvements, for example through electric vehicle fleets or improved efficiency in buildings and maintenance.

The most notable improvements are made through fleet renewal, retrofit (e.g. winglets) and weight reductions. Despite some good success, the analysis did reveal that reductions are only in the order of 0.1 to 0.3% per measure. In other words, to compensate for growth in the order of 5%, an airline would have to implement a very large number of these measures, year on year. One key finding therefore is that the incremental improvements are not sufficient to achieve notable reductions or decarbonise aviation.

Nineteen airlines are actively considering alternative fuels to supplement or replace fossil fuels. The reporting on biofuel investment varied in detail and quality, although some airlines stated significant investments into research and development and actual production of biofuel. Overall, however, the volumes of biofuel used to date are miniscule. In addition to challenges related to volume, there are wider concerns around the sustainability of biofuels and the net carbon reduction they can deliver once broader carbon cycle effects are taken into account.

Airlines are engaging into carbon offsetting programs as one way to mitigate their climate impact, but also to engage environmentally aware customers. Overall, reporting on implementation is still rudimentary, with only 28 airlines making reference to carbon offsetting, and only one third of these reporting on customer uptake and actual quantities offset. To fully capitalise on travellers' willingness to contribute to climate mitigation, airlines will need to improve their offsetting systems and communication. Drawing on high quality credits that lead to genuine, additional and long-term climate benefits is essential.

The report concludes with some critical remarks on the need to accelerate efforts of true decarbonisation in the aviation sector. Governments play some role in accelerating change, be it through policy incentives, taxes, or investment into research and innovation. In the meantime, managing demand, for example, through improved air-rail connectivity, is an important measure to reduce transport emissions. Such shifts could also indicate future more drastic transformation of aviation business models as providers of 'access' rather than physical mobility.

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Introduction

1.1 Context of aviation emissions

Aviation has been described as a "'tough-nut' source of pollution" (Gabbatiss, 2018, p.1), facing considerable challenges in reducing its carbon emissions. Whilst there are presently limited substitutes for aviation fuel, airlines are putting considerable efforts into improving fuel efficiencies. Ongoing growth, however, is leading to growing emissions, to the extent that aviation could make up 22% of global emissions by 2050 (Cames et al., 2015).

The Paris Agreement sets the target of keeping warming well below 2 degrees Celsius (°C) by reaching net zero[1] emissions by the middle of the century (UNFCCC, 2016). Whilst domestic emissions fall within jurisdictions of national governments and therefore are subject to Paris commitments, international emissions are excluded from the Accord. Instead, these are addressed by mechanisms developed by the International Civil Aviation Organisation (ICAO) in collaboration with the International Air Transport Association (IATA).

About 62% of aviation emissions occur in international air space (Cames et al., 2015), and a 'basket of measures' has been put in place to deal with these. In particular, ICAO's Carbon Offset and Reduction Scheme for International Aviation (CORSIA) involves a market mechanism whereby airlines will purchase carbon credits to compensate for emissions that exceed 2020 levels on specific routes (IATA, 2013). Such 'carbon neutral growth' poses inherent challenges due to the political complexity of reporting and implementation (Lyle, 2018) and the fact that offsetting does not help decarbonise aviation (Becken & Mackey, 2017). For an overview and assessment of the impact of CORSIA, see CarbonBrief (2019) and Lee (2018).

Airlines are facing mounting pressure from governments, the public and media. In October 2019, the United Kingdom's House of Commons Environmental Audit Committee opened an inquiry into sustainable tourism, noting specifically the country's goal of reaching net zero emissions by 2050, *including* aviation

1. Net zero means to achieve a balance between anthropogenic emissions and their removals through carbon sinks by 2050. Carbon sinks absorb carbon and the most important natural ones are plants, the ocean and soils. Research is exploring man-made sinks; however, negative-emissions technologies are in their infancy.

and shipping as outlined in the amended UK Climate Change Act. In particular, the Committee is seeking inputs to inform the development of the aviation strategy to 2050. Elsewhere, the UK Department of Transport (2019) is calling for evidence on the use of carbon offsetting in transport and disclosing carbon information to customers at various stages of the booking process. The New Zealand Parliamentary Commissioner for the Environment is also currently leading an investigation into the sustainability of tourism, including its carbon footprint.

The incentives to invest into 'decarbonising aviation' are accelerating. Other actors that form part of the broader 'aviation ecosystem' are also increasing their involvement in developing solutions for reducing greenhouse gas (GHG) emissions, for example aircraft manufacturers, airports, aviation technology providers (e.g. for data-driven solutions), alternative fuel suppliers, and booking systems. Destinations are also increasingly interested in understanding their exposure to carbon risk (Becken & Shuker, 2018).

> *We must find a way to decarbonize aviation. This is for our generation to do. It's expected of us by the flying public and by society.*
>
> Airbus CEO, Guillaume Faury
> — at the Paris Air show in June 2019

1.2 The urgency of climate action

The most recent 1.5 degrees Celsius (°C) report by the Intergovernmental Panel on Climate Change calls for drastic reductions in GHG emissions. It concludes that staying within the safe boundaries of global warming to no more than 1.5 °C demands:

> *...rapid and far-reaching transitions in energy, land, urban and infrastructure (including transport and buildings) ... [of an] unprecedented scale.*
>
> Intergovernmental Panel on Climate Change, 2018, p. 17

To meet the target, emission reductions would have to be in the order of 45% between 2010 and 2030, with 'net zero emissions' by 2050. Current pledges made by countries indicate that the world is on a warming path of 3 to 3.5 °C by the end of the century, with potentially catastrophic consequences. Recognising that we may not reach the necessary rate of decarbonisation, an international team of scientists around Johan Rockström from the Stockholm Resilience Institute has modelled a so-called 'Hothouse Earth' scenario in which temperatures will in the long term stabilise at about 4-5 °C higher than pre-industrial temperatures. In such a scenario, sea level will be 10-60 metres higher than presently. The lead author concludes that places on this planet will become uninhabitable. Avoiding the 'hothouse' scenario would require *"a redirection of human actions from exploitation to stewardship of the Earth system"* (Stockholm Resilience Centre, 2019).

A paper in *Nature Climate Change* published in March 2019 (Lamontagne et al., 2019) suggests that under an optimistic climate sensitivity (i.e. how the global climate system responds to increased concentration of greenhouse gas

(GHG) emissions in the atmosphere), several possible mitigation pathways to a 'tolerable future' exist. However, as climate sensitivity increases, these pathways become increasingly narrow, to the extent that they have already closed. The authors conclude that given their large range of simulations and using a wide range of parameters (e.g. what percentage of GDP is spent on carbon reduction), *"rapid abatement growth is needed to hedge against a high climate sensitivity and increase our chances of achieving a tolerable future"* (p. 292).

To address the *"existential risk to humanity", The Club of Rome* (2018, p. 5) calls for a Climate Change Emergency Plan. One of the main barriers identified is not the ability to act, but the political and moral willingness to act. The current focus on incremental change and maintenance of status quo has been critiqued by Becken (2019) in her assessment of why decarbonisation of tourism presents a major systemic challenge.

Sometimes, action by industry and government is slowed down by scientific uncertainty around particular details of climate projections or models. One pertinent example is the impact of non-CO_2 emissions by aircraft on global warming (Lee, 2018).

> *Under a business-as-usual trajectory, the United Nations' International Civil Aviation Organization (ICAO) expects aviation emissions to roughly triple by 2050, at which time aircraft might account for 25% of the global carbon budget.*
>
> In International Coalition for Sustainable Aviation, 2018

↑ Protesters march with signs along Market Street during the San Francisco Youth Climate Strike, on 15 March 2019. Source: https://commons.wikimedia.org/wiki/File:San_Francisco_Youth_Climate_Strike_-_March_15,_2019_-_34.jpg

1.3 Operating environment

Whilst airlines still see continued growth in demand, they are also operating in a fast-changing environment. An increasing number of countries are implementing policies that seek to curb demand, whilst at the same time raising revenues for federal budgets. Table 1 provides an overview of key countries that impose some form of aviation tax.

A recent report by the NGO Transport & Environment highlighted the extent to which airlines in Europe are subsidised. Examples include the exemption of airline tickets from Value Added Tax, infrastructure investments to access the airport, exemption of kerosene from taxation, and investments into airspace management. There is increasing pressure on airlines to demonstrate their contribution to national economies, as well as global carbon reduction goals.

> *A well-designed environmental tax increases the price of a good or activity to reflect the cost of the environmental harm that it imposes on others. The cost of the harm to others – 'an externality' – is thereby internalised into market prices. This ensures that consumers and firms take these costs into account in their decisions.*
>
> OECD, 2011

TABLE 1. COUNTRIES THAT IMPOSE SOME FORM OF TAXATION OR LEVY ON AVIATION WITH THE (PARTIAL) GOAL OF REDUCING CO_2 EMISSIONS

COUNTRY	TAX	DETAILS OF TAX	EXPECTED IMPACT
Sweden	Air passenger tax (departure tax)	SEK 60 (€6) on domestic routes and SEK 400 (€39) on long haul routes	Reduce GHG emissions by 5% by reducing airline traffic in Sweden by between 450,000 to 600,000 passengers per year.
United Kingdom	Air passenger duty (APD)	Varies according to cabin seat pitch and distance flown. In 2019 this was from 13 to 78 pounds under Band A travel and from 78 to 515 pounds in Band B travel; in 2020 Band B increases from 80 to 528 pounds. Exemptions apply.	Internalise the environment costs of air travel; but later positioned as revenue raising tool.
Germany	Aviation tax	As of January 2018: Countries listed in Anlage 1 zum LuftVStG, €7.46; countries listed in Anlage 2 zum LuftVStg, €23.31, all other countries €41.97. The tax will increase 1 January 2020.	Raised €1.2 billion for the federal budget in 2018. Increases will pay for reduced tax on rail travel.
Norway	Air passenger tax	Low Rate (destination in Europe) = NOK 75 per passenger. High Rate (other destination) = NOK 200 per passenger.	
Switzerland	Swiss emissions trading scheme	Collection of aviation data since 1 July 2017 for domestic flights within Switzerland or flights from/to EU EEA. A carbon tax similar to the one in Germany is being discussed.	
Austria	Air transport levy	New levy as of 1 January 2018 is €3.50 for short haul, €7.50 for medium haul, and €17.50 for long haul. Levies were halved in 2018.	
France	"Eco-tax"	€1.50 for domestic and within the European Union, €18 for business class flights out of the European Union.	Raise circa €180 million to be invested amongst others in rail.
Netherlands (re-introduced)	Dutch aviation tax	Flat rate of €7 per departing passenger. Currently a draft to be debated by House of Reps and Senate.	Revised tax in order to make aviation more sustainable. Expected tax revenue €200 million.

Aviation is increasingly discussed based on equity considerations. A recent report by the United Kingdom Committee on Climate Change (CCC) reported that the top 10% of frequent flyers in England took over 50% of all international flights in 2018, whereas about half of the population did not undertake any international travel. The CCC recommended tougher regulations on air travel, for example through a frequent flier levy (Kommenda, 2019). The unequal distribution of flying as a privilege of the developed world can be visualised by contrasting emissions with population share (Figure 1).

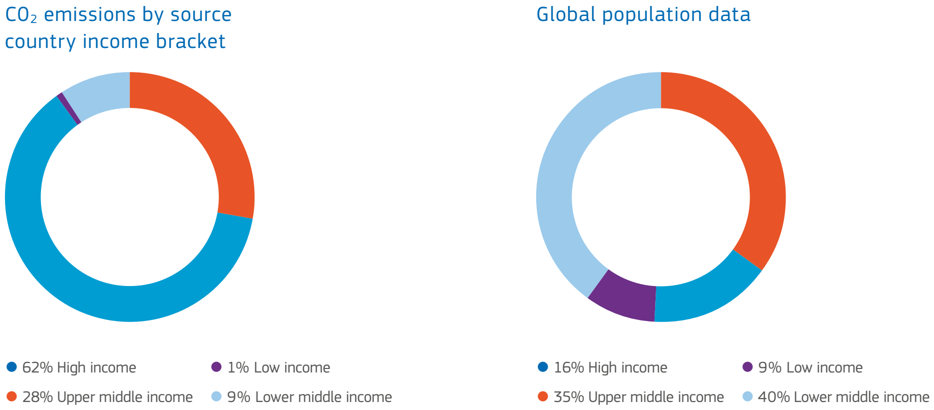
Consumer attitudes towards flying are changing in many parts of the world. Most prominently, the movement of 'flight shame' has led to increased debate around the ethics of flying. Originating in Scandinavia, 'flygskam' manifests in measurable reductions in outbound Swedish air travel (Flight Leader, 2019). Instead, rail travel saw increased popularity. The Swedish example demonstrates that in some countries, attitudes are translating into behaviours.

Addressing carbon emissions from air travel is also being considered more proactively by educational organisations (Table 2). Discussions on how to cut back on flying have become prominent on social media. These can be followed by searching for a dedicated hashtag on #flightshame.

'Fly responsibly·' campaign by KLM

In June 2019, and to celebrate the airline's 100th anniversary, **KLM** launched a campaign on flying responsibly. Supported by a promotional video, the campaign asked a variety of questions, including to raise awareness of whether people need to meet face to face, whether the train would be an alternative, or if passengers could contribute by offsetting their carbon emissions.

FIGURE 1. CONTRASTING CO_2 EMISSIONS FROM PASSENGER AIR TRAVEL WITH POPULATION BY DEVELOPMENT STATUS



↑ Source: International Coalition for Sustainable Aviation, 2018, using data from the United Nations and the World Bank in addition to their own modelling.

TABLE 2. OVERVIEW OF INITIATIVES TO REDUCE AIR TRAVEL EMISSIONS

ORGANISATION	INITIATIVE
European Citizens' Initiative	Student-driven campaign to lobby the European Union to impose a tax on aviation kerosene or fuel Started a petition called FlyingLess.
Council of the American Association of Geographers (AAG)	Received a petition signed by 234 AAG members to take far-reaching action to reduce CO_2 emissions related to the Annual Meeting attended by 9,000 delegates.
Department of Geography, Planning & Environment at Concordia University in Montreal	"Flying Less Policy". All faculty members in the department disclose their annual flying activity (the results of which are public, collectively and anonymously) Staff need to prioritize travel-free meetings and video conferencing over physical travel and, when travel is needed, collective forms of ground transportation for destinations within 12 hours of Montreal.
Stay Grounded network (various civil society groups and the Institute for Ecological Sciences and Technology in Barcelona)	A flight-free "Degrowth in Aviation" conference in Barcelona from July 12-14, 2019.

1.4 Objectives of this White Paper

The aim of this White Paper is to assess the progress of airlines in their efforts to reduce carbon emissions. The recent report by the Transition Pathway Initiative (TPI) on the environmental performance of the Top 20 airlines (Dietz et al., 2019) made it clear that carbon emissions have moved from being an environmental and moral issue to being one of central concern to business risk management (Doyle, 2019).

Recognising aviation's contribution to climate change is therefore increasingly central to decision making, especially in areas where growing risk of carbon exposure will present major conflicts or undermine performance.

To facilitate this study, Amadeus delivered aggregated travel information that helped to produce specific graphs and check the consistency of the analysis, in combination with other sources of data. This White Paper will:

- Present key trends in the aviation industry that are relevant for understanding the context of decarbonisation.
- Assess the extent of efficiency gains made by airlines and their global impact.
- Examine key areas of carbon reduction reported by airlines.
- Highlight innovations that could be replicated or scaled up.
- Explore current levels of customer engagement, particularly in relation to carbon offsetting.

In its conclusion, the White Paper aims to propose ways for accelerating the climate change mitigation activities of the aviation industry.

> *Investors have a clear message to the aviation sector: when it comes to carbon performance, they must be in it for the long haul.*
>
> Faith Ward — from the UK Environment Agency Pension Fund

2

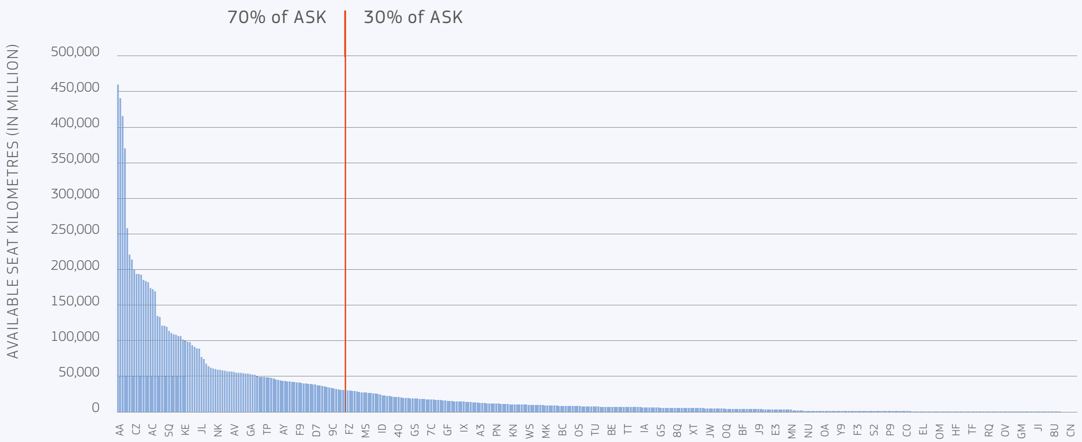
Approach: data and analysis

This report draws on several data sources to provide a picture of airlines' decarbonisation efforts. The data and associated analyses are briefly outlined below. These are complemented by information available from other secondary sources, for example IATA.

The analysis focused on the largest airlines measured through Available Seat Kilometres (ASK). More specifically, all airlines that contributed to the top 70% of ASK (see Figure 2) were included. This resulted in a set of 58 airlines, ranging from American Airlines with 460,102 million ASK to Air New Zealand with 45,763 million ASK.

Data on ASK was also used as a common denominator to derive an efficiency metric (i.e. CO_2 per ASK) and compare changes between 2017 and 2018. The ASK for those years refer to the calendar year, but for some airlines different reporting periods applied. This may have led to a situation where 2017 ASK were contrasted with emissions occurring in 2016/17, and likewise 2018 ASK may have linked 2017/2018 emissions. Whilst this introduces a slight inaccuracy, the overall trends should not be affected. An effort was made to reconcile ASK and emission data as best as possible.

FIGURE 2. RANKING OF AIRLINES BASED ON ASK IN 2018



↑ Note that airlines that provide less than 1 million ASK are not visualised; further, not all airline codes are shown on the x-axis.
Source: own production based on aggregated data from Amadeus and airlines.

2.1 Public reporting

2.1.1 CDP (formerly Carbon Disclosure Project) reports

In 2018, a total of nineteen airlines provided information to the CDP, a not-for profit charitable organisation that reports on global disclosures on environmental impacts. The reports can be accessed on the CDP website (https://www.cdp.net/en/scores). Information on Scope 1 (direct fossil fuels, mainly aviation fuel) and Scope 2 (electricity) was extracted, alongside other information, for example around targets and metrics used by the airline to monitor performance. Reporting by different scopes complies with the standards of the Greenhouse Gas Protocol.

Unfortunately, the reporting is highly inconsistent and included some obvious errors (e.g. in relation to scale where kilogram might have been reported as tonnes or vice versa). For this reason, the analysis of CDP reports for comparative purposes was less fruitful than expected.

2.1.2 Airline reports and websites

In addition to CDP reports, an Internet search was conducted to identify information on carbon emissions for the largest 58 airlines that account for 70% of total global available seat kilometres (see above). In addition to these 58 airlines, the following airlines were added to the sample because they filed a CDP report and were not already part of the leading 58; they were: Finnair, Thomas Cook, TUI, and Pegasus Airlines. Information on these five airlines is included in an assessment of total emissions, but the airlines are excluded from further analysis.

The web search took place between May and July 2019, and any information released by airlines thereafter is not included in this present analysis. The search first sought to identify any type of company report that would contain relevant carbon information. Reports could be dedicated Sustainability or Corporate Social Responsibility (CSR) Reports, Annual Reports or any other type of information provided to the public. In addition, the airlines' websites were systematically searched for information on climate action. This often led to additional data being collected. For example, some airlines provided information on carbon offsetting programs on their website (or at greater detail) and not in their reports.

The final database included data on emissions (extracted from the CDP where possible and other sources for the remaining airlines), reduction targets, corporate structures, efficiency improvement measures, investments into biofuel and carbon offsetting schemes and other initiatives. Details on other innovative measures were recorded for further analysis.

Airlines that quantified their insights into emissions reductions were of significant interest. Not all initiatives were quantified, and some airlines reported reductions in ways that did not allow for broader conclusions. For example, some airlines provided information on the percentage improvement in efficiency (e.g. 2%) for a given aircraft in response to installing winglets[2]. Others reported that they managed to save a certain amount of weight (in kilograms) on particular routes or for specific aircraft. Whilst these improvements are interesting, in themselves they do not allow for calculations of total CO_2 saved measured in tonnes of CO_2 per year, and relative to total emissions of this airline.

Some airlines disclosed the savings in CO_2 emissions for a specific measure and this helped to compare the impacts of a change relative to other airlines and relative to total emissions. Some airlines expressed the annual savings in terms of fuel. In those cases, emission factors from the United States Energy Information Administration helped to convert these into CO_2 emissions (https://www.eia.gov/environment/emissions/co2_vol_mass.php).

2. Japan Airlines, for example, reported that their Boeing 787 fleet reduces fuel use by 15-20%. They also provided information on the share of fuel efficient aircraft in FY 2016 (which was 65%), in 2017 (71%) and projections for 2020 (at 81%). Whilst this indicates a trend of improvement and relative reductions in emissions, it is not possible to clearly determine carbon savings in tonnes of CO_2. From an analytical point of view, this information is only moderately useful.

2.1.3 Limitations and scope of the study

This study uses data published by airlines. This poses natural limitations in the sense that such data provides an approximation rather than a comprehensive audit of airline activities or rankings in relation to environmental effort or efficiency improvements.

When trying to elicit an airline's emissions it became clear that not all airlines identified whether they reported on aviation fuel emissions only, total Scope 1 (which could include fuel use from land vehicles, amongst others), or total emissions. Since airlines tended to report Scope 1 emissions, this was used as a common denominator. For six airlines, this may not be completely accurate as the provided figure was not further explained in terms of scope. The difference between scopes is minimal as an airline's emissions are dominated by the burning of aviation fuel. An analysis of those airlines that quantified different scopes shows that 99.6% of airline emissions are Scope 1, with the remaining 0.4% being related to electricity consumption (Scope 2). The emission data reported by airlines are used in this White Paper without further ability to verify their accuracy.

The analysis of emissions was hampered by the fact that some airlines reported emissions for the whole group, whereas others provided specific information for individual brands that operate under their own IATA code. The measure of ASK referred to a specific IATA code and airlines where it was not possible to reconcile the two measures were excluded from analyses related to carbon intensity. For example, the Lufthansa Group reported emissions as a whole, whereas ASK referred to the individual companies under that umbrella. In some cases, it was possible to reconcile the numbers, for example in the case of Norwegian where ASK were summed up for the Norwegian Air Shuttle and Norwegian Air International. IAG as a group reported on emissions for both British Airways and Iberia. Because a separate report was found for Iberia, it was possible to deduct British Airways emissions. In total there were 36 airlines for which enough information was available to derive insights into efficiency gains between 2017 and 2018.

> *Whilst more airlines now report on their carbon emissions and decarbonisation activities, the quality of reporting is still low. Even submissions filed with the CDP contain inconsistencies and errors. For other reports, formats and coverage differ widely and it is challenging to obtain a coherent picture of progress.*

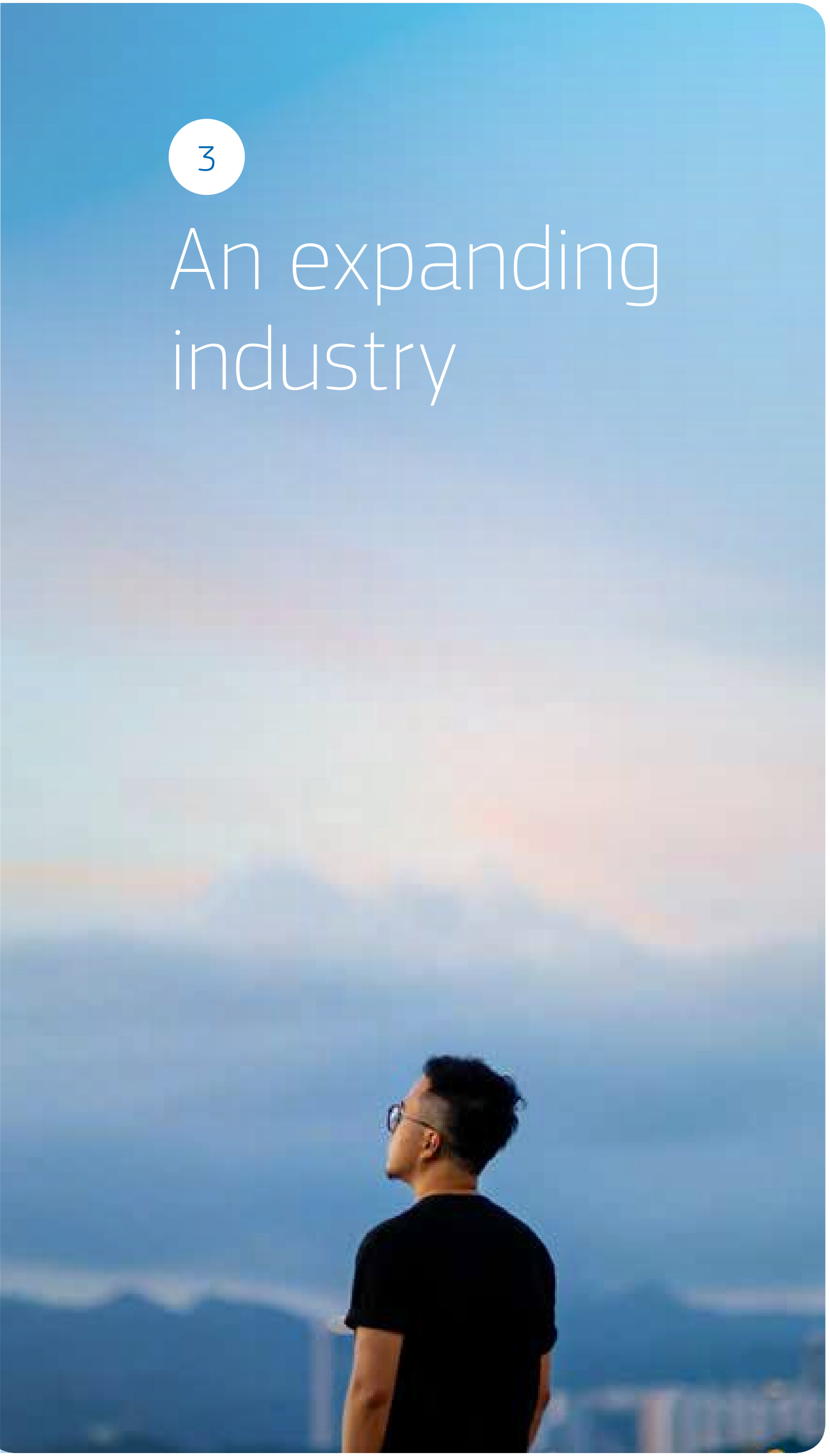
With those limitations in mind, the analysis of the data helps to identify specific issues and trends in areas that are within the scope of this work, like: overall emissions from aviation, identification of the main areas in which airlines are working to reduce emissions and identification of initiatives through which action could be accelerated to reduce emissions from aviation.

Alaska Airlines

Acquisitions and mergers complicate carbon accounting and performance targets. Alaska Airlines reported improvements in carbon intensity in 2017 by 13% over baseline, on track towards their 2020 goal of 17% improvement. Total emissions increased because of the integration of Virgin America's fleet, leading to a slight adjustment in the company's target. Alaska Air has a comprehensive efficiency improvement program in place.

3

An expanding industry



The aviation industry can be described as fast-growing and efficiency focused. Using IATA data, Figure 3 presents some key top line numbers that encapsulate sector growth.

Table 3 provides some more insight into the longer-term trends of growth and carbon emissions. Whilst absolute emissions continue to increase, the carbon intensity per passenger has improved. Note that the emissions shown in Table 3 include both passenger and freight transport.

FIGURE 3. KEY TRENDS CHARACTERISING THE AVIATION INDUSTRY IN 2018 COMPARED WITH THE PREVIOUS YEAR

+6.9%
passengers

207 kg CO_2
emissions per average passenger

+4.7% flights

+6.1% capacity

+5.2%
in total CO_2 emissions

↑ Source: IATA, 2019

TABLE 3. AVIATION STATISTICS (IATA, 2019)

	Absolute numbers or percentage increase over previous year	2013	2014	2015	2016	2017	2018	F2019
Volume - demand	Number of passengers (million)	3,145	3,328	3,569	3,817	4,095	4,378	4,579
	Increase in passengers (%)		5.8	7.2	6.9	7.2	6.9	4.6
Capacity - supply	Capacity growth (% increase)	4.5	5.3	6.3	6.4	6.1	6.1	4.3
	Number of flights (million)	32	33	34	35.2	36.4	38.1	39.4
	Number of flights (% increase)		3.1	3.0	3.5	3.4	4.7	3.4
Carbon dioxide emissions	CO_2 emissions (million tonnes)	710	733	774	812	860	905	927
	CO_2 emissions (%)		3.2	5.6	4.9	5.9	5.2	2.4
	CO_2 per flight (tonnes)	22.2	22.2	22.8	23.1	23.6	23.8	23.5
	CO_2 per passenger (kilograms)	225.8	220.3	216.9	212.7	210.0	206.7	202.4

↑ Note: Passengers in the IATA statistics reflects the number of sectors flown. Considering that most people fly at least two sectors (to the destination and back), and some require multiple connections, the passenger numbers in the Table above are likely to be represent more than twice the number of actual individual people who have flown. For example, the volume of travellers in 2018 is likely to be closer to 2 billion, rather than the reported 4.4 million 'passenger sectors'.

The growth in demand for air travel is not surprising. The real cost of an airfare has reduced substantially in the last decades. The price of a ticket, alongside income (often measured as Gross Domestic Product in a country of origin) is a key driver of demand for (air) travel. Most transport forecast models are based on price and income (e.g. Airbus, 2019) in addition to several other factors. These include, for example, different business models (low-cost airlines), increased competition, fuel prices, efficiencies (e.g. through alliances) and economies of scale. Figure 4 shows average airfares in the USA between 1995 and 2018.

Drawing on data from Expedia, The Economist (2018) reported on substantial reductions in fares in the last four years, especially for transatlantic and long-haul flights. For example, since 2014:

-18% New York → Frankfurt

-8% Hong Kong → Singapore

-34% London → Dubai

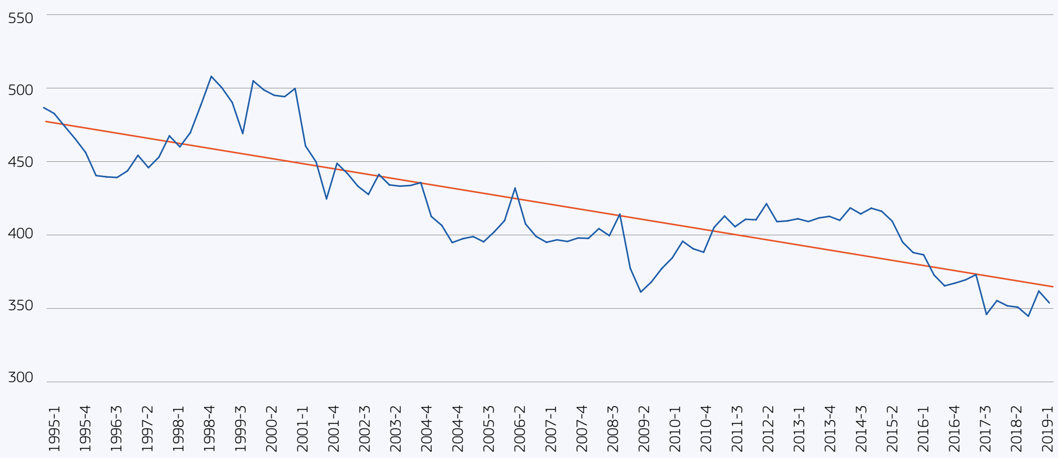
-47% Los Angeles → Paris

In conjunction with falling airfares, incomes have increased, at least for a growing middle-class in emerging economies. This means that a larger number of people have disposable income to afford travel. The world has become increasingly connected, with business and families spread across the globe, inducing increasing needs and desires for people to travel. The rise of social media – in conjunction with considerable advertising by airlines and tourist destinations – is likely to contribute to the growing 'social norm' and imperative of air travel.

In summary, the aviation industry has seen exceptional growth – well beyond average economic growth rates, partly driven by a decrease in the price of airfares. With this came a substantial increase in CO_2 emissions, despite improvements in efficiency.

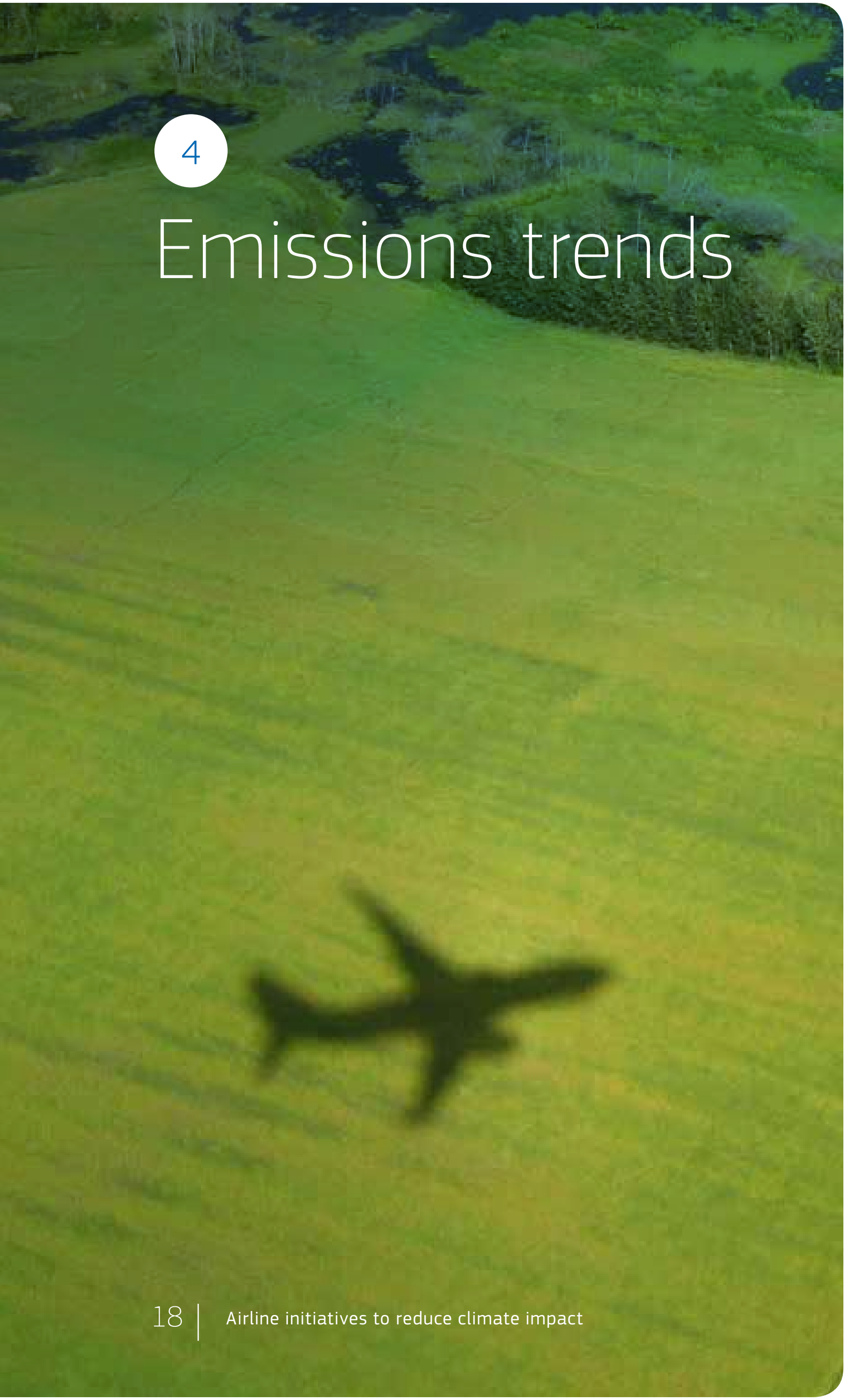
> *Air travel also grows because it is subsidised, thus creating the basis for a social norm of cheap flights.*
>
> Gössling et al., 2019

FIGURE 4. U.S. AVERAGE AIRFARE (USD)



↑ Average price of an airfare in the USA, inflation adjusted and visualised with a trendline.
Source: https://www.transtats.bts.gov/AverageFare/Default.aspx

↑ The airline industry has a long history of advertising travel with the connotation of luxury and the 'exotic', and it still benefits from the image of privilege and status – even when today's aviation has become a highly affordable commodity. Source: https://www.flickr.com/photos/x-ray_delta_one/9298783988, free to use.



4

Emissions trends

4.1 Total emissions

What matters for climate change is the absolute amount of CO_2 that is emitted into the atmosphere by airlines. Publicly available top-line aviation statistics, such as those compiled in Table 3, typically include both cargo and passenger transport activity.

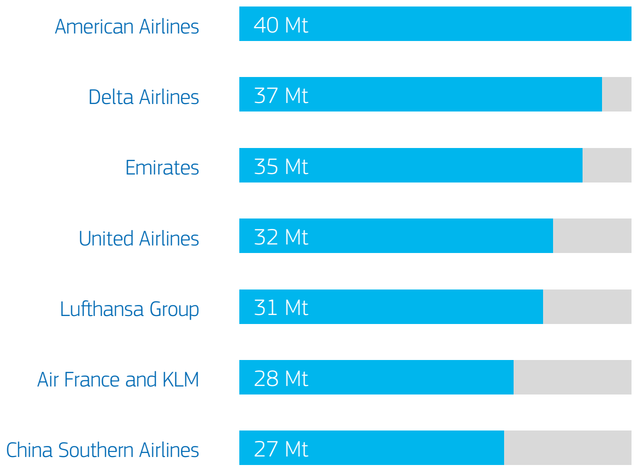
To gain a better understanding of passenger aviation emissions, the Global Sustainable Tourism Dashboard took a bottom up approach, whereby monthly passenger volumes by individual itineraries where used to estimate emissions. Figure 5 provides a visualisation of the distribution of emissions by country. In total, 2018 emissions were estimated to be 667 million tonnes (Mt) of CO_2. This represents an increase of 25.7% compared with emissions in 2015.

FIGURE 5. GLOBAL CO_2 EMISSIONS FROM PASSENGER AVIATION BY COUNTRY

↑ Source: Global Sustainable Tourism Dashboard, 2019, for interpretation see www.tourismdashboard.org

The International Coalition for Sustainable Aviation (2018) provided a higher estimate of global passenger aviation emissions of 747 Mt (their model is more comprehensive and includes taxiing at the airport, amongst others). The data suggest that about two-thirds of all flights were within the same country, and these domestic flights contributed one-third of global revenue-passenger kilometres and 40% of CO_2 emissions of passenger air travel. International travel made up the remaining 60%, or 451 Mt of emissions.

Whilst not all airlines report their annual emissions, the analysis provided data for 42 airlines (Appendix). The Top 20 airlines emit a total of 450 Mt of CO_2. This is the same amount as all international passenger aviation emissions. The largest emitters are:



There is no universally utilised metric to measure the carbon intensity of air travel, making comparisons between airlines difficult.

4.2 Improvements

Improvements in carbon performance of airlines are typically reported in the form of relative metrics. Carbon intensity or efficiency can be measured in various ways. The CDP reports reveal that airlines use a range of metrics, including:

- Kg CO_2 per revenue tonne kilometre (e.g. Virgin Atlantic, Cathay Pacific, Finnair, Lufthansa, Eva Air, Japan Airlines, Jetblue Airlines, Pegasus)
- Kg CO_2 per revenue passenger kilometre (e.g. Iberia, British Airways, Air France, Scandinavian Airlines, Thomas Cook, TUI)
- Kg CO_2 per passenger mile (United Airlines)
- Litres of jet fuel per revenue tonne kilometre (Air Canada, ANA)
- Tonnes CO_2 per tonne mile (American Airlines)
- Gallons jet fuel per tonne mile (Delta)
- Tonnes CO_2 per 1000 revenue tonne miles (South West Airlines)

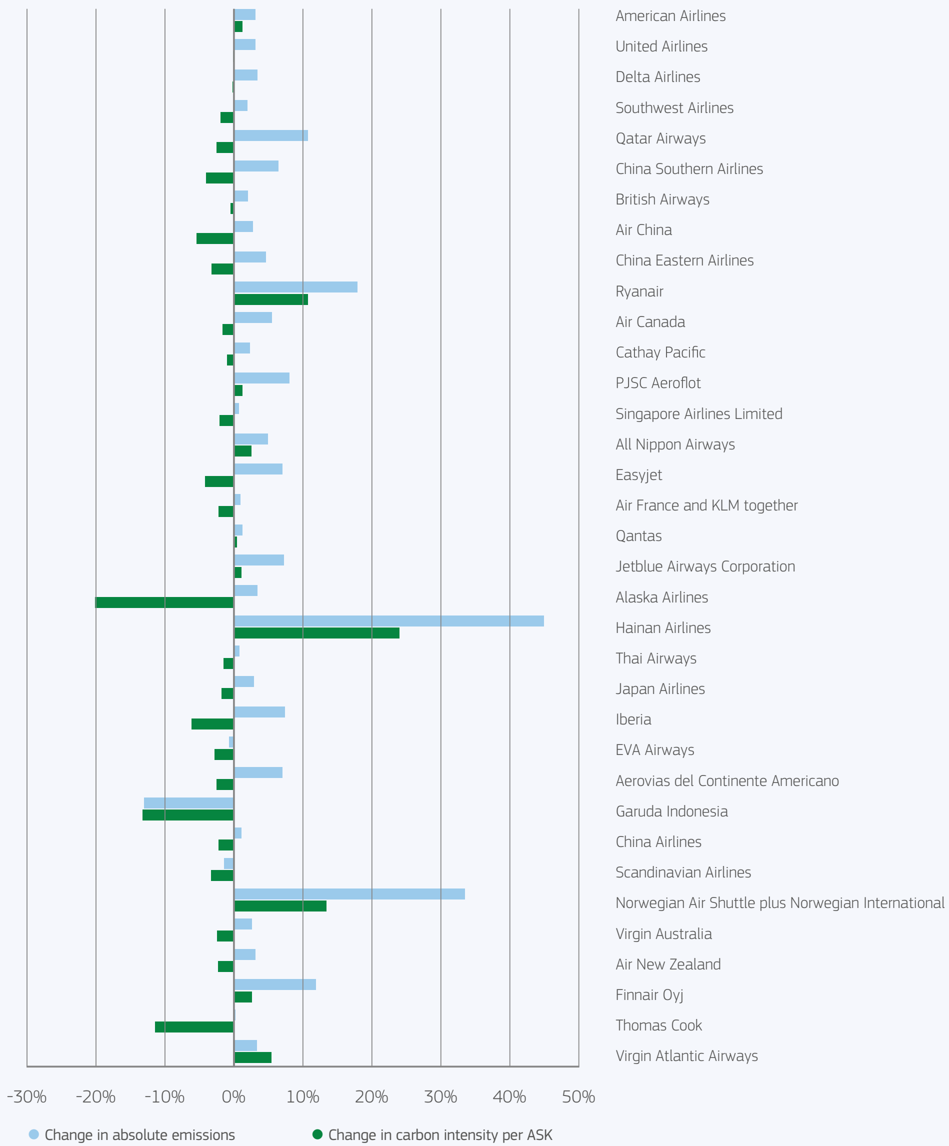
There is not a single common measure in the industry. The analysis below opted for CO_2 emissions per ASK because it is the most transparent variable. It does not consider effects of occupancy or cargo.

Most airlines increased their absolute emissions between 2017 and 2018, but at the same time most were able to demonstrate improvements in efficiency. In total, 35 airlines provided some information on emissions for 2017/18 and 2016/17 that allowed assessment of changes in terms of absolute and relative emissions. Figure 6 shows improvements in carbon intensity, measured as CO_2 emissions per seat kilometre in green, contrasted with absolute increases in blue (largely on the right-hand side of the axis).

The aviation industry has set a goal of improving fuel efficiency by 1.5% per annum, and this is achieved by a combination of measures. The Transition Pathway Initiative report highlighted that many of the largest airlines were able to demonstrate minor improvements. For example, Lufthansa as one of the leading airlines acknowledged in the report reduced emissions from 127 grams of CO_2/pkm to 120 g/pkm. EasyJet went from 82 to 79 g/pkm in that same time (Dietz et al., 2019).

It is possible to gain an approximation of airline efficiency gains by comparing 2017 and 2018 emission data and considering growth in ASK. More specifically, by drawing on 2017 data for both emissions and ASK it is possible to calculate each airlines' carbon intensity for the year 2017. This 'older' intensity can then be applied to the more recent 2018 ASK to estimate how much carbon *would* have been emitted in 2018 under the assumption that *no improvements* in efficiency had been made. This can then be contrasted with the actual emissions for 2018.

FIGURE 6. CHANGES IN CO_2 EMISSIONS



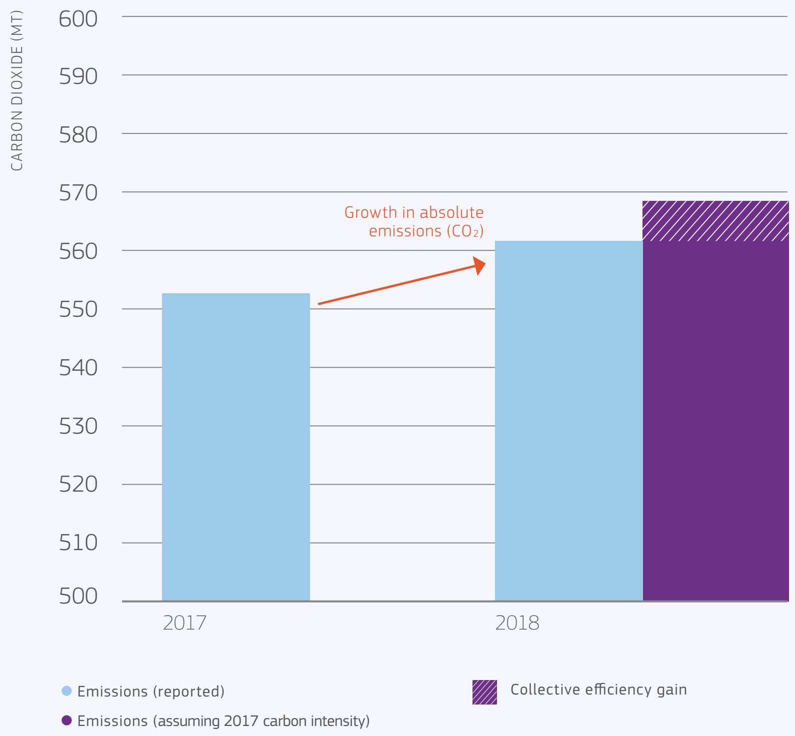
↑ Changes in absolute and relative emissions per available seat kilometre between 2017/18 and 2016/17 for 35 airlines.

Figure 7 illustrates this exercise, whereby the light blue bars represent actual emissions reported, and the striped purple bar shows the theoretical, extrapolated emissions. The 2018 emissions are lower than what would have been expected without improvements. The collective efficiency gain based on 35 airlines was 1.04%.

Future projections of aviation emissions take into account exactly this combination of growth versus efficiency gain. CarbonBrief 2019, for example, estimated that aviation emissions will increase between 2.4 and 3.6 times by 2050 compared with the present. Furthermore, should trends of ultra-long-haul and reviving supersonic continue, then carbon intensity is likely to increase.

> *Drawing on data from 35 of the largest airlines, the collective improvement in efficiency was about 1% in the last year. Whilst this is a positive outcome, it falls short of industry targets and it also is insufficient to compensate against growth.*

FIGURE 7. COLLECTIVE EFFICIENCY GAIN BETWEEN 2016/2017 AND 2017/2018



5 Carbon reduction initiatives

5.1 Reporting and targets

More than half of the largest 58 airlines report on carbon-related activities in some form or another. Whilst the majority provided company (sustainability) reports, 26 filed reports with another reporting platform, most commonly the Global Reporting Initiative (GRI) or FTSE4Good. GRI is a non-profit organisation that sets standards on sustainability reporting since 1997. FTSE4Good is part of London FTSE stock exchange containing a series of ethical investment stock indices since 2001.

The Task Force on Climate-Related Financial Disclosures provides guidance and standards for companies who seek to disclose financial climate risks in a consistent manner, with a focus on providing information to investors, lenders, insurers, and other stakeholders. Notably, the TCFD considers carbon and climate impact risks. Four airlines have signed up to the TCFD, with Air New Zealand having joined in August 2019 as the fifth airline.

Table 4 provides information on reporting channels, and reference made to specific carbon performance targets. Only 16 airlines specified targets that differed, and were usually more ambitious, from the general IATA industry targets. CORSIA, which is an emissions mitigation approach for the airline industry developed by ICAO, was mentioned by 29 airlines.

TABLE 4. OVERVIEW OF REPORTING ACTIVITIES OF MAJOR AIRLINES

TYPE OF REPORT	NUMBER OF AIRLINES	ADDITIONAL INFORMATION
(Sustainability) Report	39	Mostly in CSR or Sustainability Reports, but also as part of an Annual or Integrated Report. For 19 airlines there was no publicly available report on carbon/sustainability activities.
CDP	19	Referred to having disclosed via CDP either recently or previously.
Reporting Framework	27	Most commonly, airlines referred to the GRI, FTSE-4Good and Dow Jones Sustainability Index.
Reference made to TCFD	4	4 Airlines considered carbon as a business risk and explicitly referred to the Task Force on Climate-Related Financial Disclosures (TCFD).
Targets	34	18 Airlines reiterated the IATA targets, 16 presented additional or different targets and 24 did not specify targets.
Reference made to CORSIA	29	Mentioned CORSIA and their willingness to comply.

> *Building a 'price of carbon' into internal financial systems helps drive investment decisions towards lower carbon outcomes. Airlines that already 'internalise' carbon will be better prepared for policy instruments such as carbon taxes.*

Some airlines are accelerating carbon reduction outcomes by using an internal price on carbon. Drawing on the CDP reports, it appears that eight airlines are using this tool to incentivise change. As can be seen in Table 5, the price on carbon varies considerably.

JetBlue

JetBlue is one of the few airlines that provide a detailed Sustainability Report, disclose to the CDP and make reference to 'carbon risk' through the TCFD framework. They also specify targets beyond the industry targets adopted by IATA. These are:

- Save more than 500,000 gallons of fuel burn per year through enhanced technology.
- Support the establishment of the renewable jet fuel (RJF) industry and integrate RJF into all flight operations.
- Transition the company's wholly-owned ground service equipment to electric ground service equipment where feasible for all airport operations.

TABLE 5. AIRLINES THAT REPORT AN INTERNAL PRICE ON CARBON IN THEIR CDP SUBMISSION

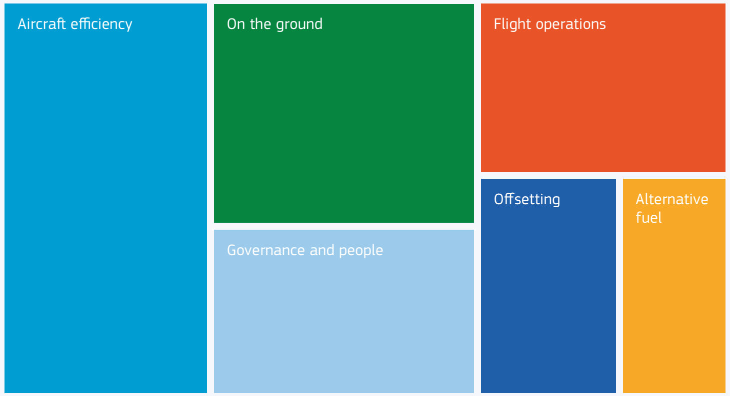
AIRLINE	USE OF INTERNAL PRICE ON CARBON
Delta Airlines	Yes (no amount provided)
Air Canada	30.32€/ton
Air France	10€/ton
Cathay Pacific	78 USD/tonne of CO_2
JetBlue Airways Corporation	8 USD/ton
Japan Airlines	30 JPY/metric ton
Finnair Oyj	12€/ton
Pegasus Hava Tasimaciligi	5€/metric ton

5.2 Overview of measures by category

Most airlines reported on a range of initiatives related to aircraft efficiency, for example, fleet renewal or the retrofitting of winglets to reduce fuel use. On the ground initiatives were also frequently reported, for example single-engine taxing at the airport. Figure 8 summarises the key areas for which airlines reported specific activities.

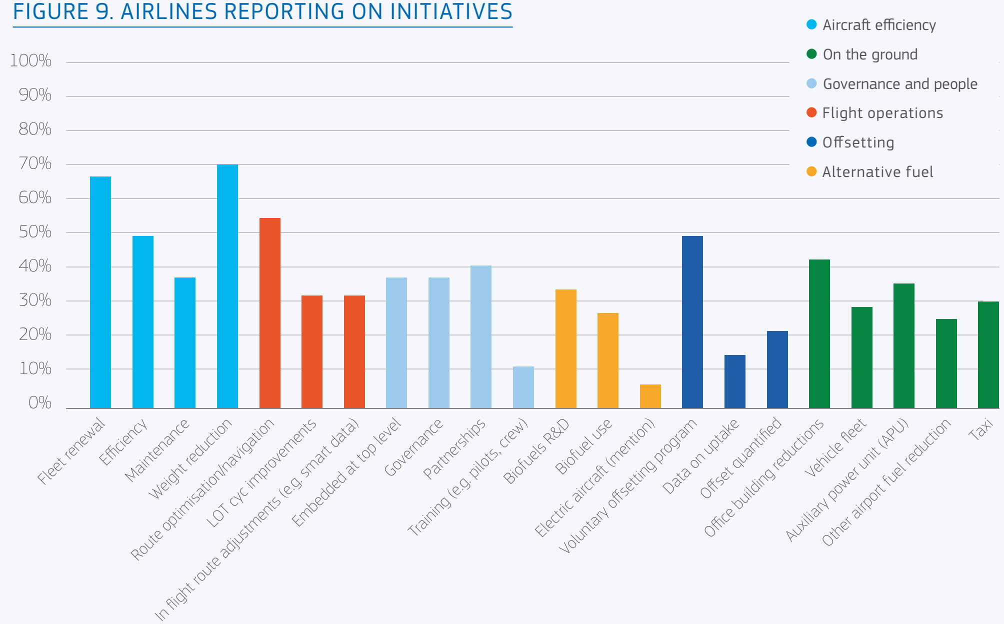
When examining carbon reduction initiatives in more detail, the most frequently reported measure is to reduce weight of the aircraft (Figure 9). Some airlines referred to generic weight reduction programs, whereas other provided considerable detail, including an attempt to quantify carbon savings (see further below). Fleet renewal is the second most popular strategy; one that probably aligns well with growth trends and increases in capacity as airlines invest in more modern (and expanded) fleets.

FIGURE 8. DECARBONISATION INITIATIVES



↑ Overview of categories of carbon reductions reported by airlines. The size of the box indicates the relative frequency of measures within each category.

FIGURE 9. AIRLINES REPORTING ON INITIATIVES



↑ Proportion of airlines that reported at least one initiative within 22 identified areas of action.

SUSTAINABILITY FRAMEWORK (AIR NEW ZEALAND)

		CHALLENGES	ASPIRATIONS	2030 GOALS	UN SUSTAINABLE DEVELOPMENT GOALS
MANAAKITANGA OUR PEOPLE	AIR NEW ZEALANDERS	New Zealand workplaces are not as reflective of the diversity of New Zealand society as they should be, particularly at the most senior levels, and as a result miss opportunities to strengthen company culture and achievements. New Zealand's health and safety record is very poor, compared to other OECD countries.	Air New Zealand is a global employer of choice and an inclusive and equitable place to work, helping 'raise the bar' for progressive workplace practices across New Zealand.	Air New Zealand is a global benchmark organisation for its employee engagement, grounded in its distinct employee experience that ensures safety and fosters high performance, innovation, community involvement, diversity and inclusion.	3 GOOD HEALTH AND WELL-BEING; 5 GENDER EQUALITY; 8 DECENT WORK AND ECONOMIC GROWTH; 15 LIFE ON LAND
	COMMUNITIES	New Zealand communities are developing at increasingly uneven rates, with some struggling to maintain cohesion, resilience, and prosperity.	New Zealand communities are thriving economically, culturally, socially and environmentally, with New Zealand businesses helping to address current disparities in per capita income and opportunity.	Air New Zealand is recognised as the most influential exponent of strategic community investment in New Zealand, helping build cohesive, resilient and sustainable communities across the country.	3 GOOD HEALTH AND WELL-BEING; 8 DECENT WORK AND ECONOMIC GROWTH; 10 REDUCED INEQUALITIES; 13 CLIMATE ACTION
KAITIAKITANGA OUR PLACE	CARBON	The world must hold the increase in the global average temperature to well below 2°C above pre-industrial levels by peaking global greenhouse gas emissions as soon as possible, or face a potentially irreversible threat to human societies and the planet. Global aviation contributes at least 2% of global emissions, and rising.	New Zealand transitions to an ultra-low carbon economy, on a pathway consistent with the world achieving net zero emissions by 2050.	Air New Zealand has stabilised emissions through carbon neutral growth post 2020, in a way that simultaneously drives significant environmental, social and economic benefits.	7 AFFORDABLE AND CLEAN ENERGY; 12 RESPONSIBLE CONSUMPTION AND PRODUCTION; 13 CLIMATE ACTION
	NATURE & SCIENCE	Rates of resource use and ecosystem degradation in New Zealand are increasing, and negatively impacting New Zealand's ability to sustain its economic and societal wellbeing.	New Zealand's ecosystems and biodiversity and restored and protected for future generations.	Air New Zealand has enabled world-leading conservation and climate science, engaging in long term strategic partnerships to help protect New Zealand's precious natural capital.	13 CLIMATE ACTION; 14 LIFE BELOW WATER; 15 LIFE ON LAND
OHANGA ORA OUR ECONOMY	TOURISM	New Zealand is at risk of losing value from a growing tourism market, due to infrastructure underinvestment, degrading natural environments, and workforce limitations, which in some cases is leading to negative community sentiment towards tourism.	Sustainability is at the heart of New Zealand's tourism value proposition, ensuring that New Zealand's 100% Pure brand position is fully aligned with national sustainability performance.	Air New Zealand has played a pivotal role in the New Zealand tourism sector delivering economic prosperity while enhancing natural and cultural resources, and providing outstanding experiences for visitors and New Zealanders alike.	8 DECENT WORK AND ECONOMIC GROWTH; 12 RESPONSIBLE CONSUMPTION AND PRODUCTION
	TRADE & ENTERPRISE	A geographically isolated economy, New Zealand must transition from commodity-led exports to a more diverse economy via high value and service-oriented products.	New Zealand businesses are cost-effectively connected to global markets, with a reputation worldwide for premium environmental, social and health and safety standards.	Air New Zealand has enabled the distribution and promotion of sustainable products and services around the globe, and has developed a world-class supply chain to support sustainable New Zealand businesses of all sizes.	8 DECENT WORK AND ECONOMIC GROWTH; 12 RESPONSIBLE CONSUMPTION AND PRODUCTION

Air New Zealand

Air New Zealand has embedded its carbon reduction strategies in a comprehensive Sustainability Framework. Key areas of focus are underpinned by targets and measurable indicators. One of the carbon targets is to achieve 5% average annual fuel efficiency improvement between 2010 and 2020. The framework also spells out for the airline to demonstrate leadership in helping New Zealand achieve a low carbon economy. Considering carbon emissions as part of a more comprehensive strategy may help to address stakeholder concerns and strengthen brand.

5.3 Quantifying savings

5.3.1 Aircraft efficiency

Several airlines quantified the CO_2 reductions they achieved. In terms of fleet renewal or engine retrofit, two airlines provided more detail. Lufthansa reported that by modifying the Trent 500 engines on its Airbus A340 aircraft through the installation of optimised components, it is expected to save 34,062 tCO_2 or 0.11% of annual emissions per year. The Trent 700 engines on the Airbus A330 aircraft are also modified, saving 13,227 tCO_2 or 0.04% of emissions. Singapore Airlines modified the Trent 900 engines on their A380 aircraft, saving 26,326 tCO_2, equating to 0.24% of Singapore Airlines' emissions per year.

One of the most popular measures is to retrofit winglets or sharklets. The savings can be relatively significant. Table 6 presents airlines' savings reported in relation to aircraft efficiency and maintenance. For example, several airlines reported the fuel saving effect of improved engine wash. Typically, savings are in the order of 10,000 to 20,000 tCO_2 per year. The key finding is that there are many ways of saving carbon, but most of them result in relatively small reductions compared with overall emissions. However, taken together these small steps may have some overall impact.

> *Airlines are implementing a wide range of measures to improve the efficiency of an aircraft. Actual savings are very small, however. If added up and implemented across the whole industry the gain could be more substantial.*

Hainan Airlines provided detail on the different ways it achieved weight reductions:

- New carbon brakes for the 787 led to reductions of 112 kg each.
- A new BCCC aviation coating system helps extend the coating cycle and reduce pollutant discharge during spraying. The 5-layer coating can reduce the weight of an aircraft by 15 kg.
- Lightweight lifeboats: adoption of more efficient gas cylinders and reduced number of cylinders in each lifeboat.
- Lightweight ULD: According to the average container/pallet per plane, light/ultralight ULD that reduces the weight of each aircraft by 320 kg (annual reduction of 290 tonnes).
- Lightweight crew equipment reduces aircraft weight by 7,249 kg and a carbon emission reduction of around 900 tons.

Reducing weight is a key focus of airlines (Table 6). Optimal fuel load management by Asiana Airlines, for example, led to CO_2 reductions equivalent to 0.36% of annual emissions. Other weight reduction measures include initiatives such as:

- Improving fuel contingency management.
- Water upload management and other ways of 'rightsizing'.
- Paper free cockpit (electronic flight bags) and no inflight magazines.
- Lightweight equipment, for example for containers or seats, carpet and crew uniforms.
- Lighter wait paint/ coating.

Again, gains are usually small. For example, KLM's inflight efforts to reduce the weight enabled a CO_2 reduction of around 13,500 tonnes in 2017 (0.05% of KLM's emissions). This includes reducing the weight of cargo and cockpit paperwork, spare magazines, galley equipment, and carrying smaller stocks of liquids.

FLEET RENEWAL, EFFICIENCY AND ABSOLUTE EMISSION REDUCTIONS?

Commercial aircraft remain in an airline's fleet typically for 25-30 years. More recently, replacement age for carriers have been around half this time to reduce maintenance expenditure, fuel intensity and deliver better consumer products. In doing so, and in response to greater awareness of airlines as significant polluters, airlines generally tout environmental credentials such as progressively lesser noise footprint and in-cabin noise, lower fuel consumption and the use of lightweight materials.

Increases in aviation fuel costs, lightweight materials and newer engine technology with 14-25% lower emissions led airlines to replace quad-engined aircrafts (e.g. Boeing 747), with wide-body twins such as the Boeing 777s and the A330neos, and more recently the Airbus A350s and Boeing 787 Dreamliners that matched or bettered the range of the quad-jets. These jets can fly directly to more city pairs more profitably. Emirates in February 2019 cancelled 39 Airbus A380 orders and instead placed an order for 70 A350 and A330neo aircrafts, focusing on increasing frequencies and better payload per sector. Airline operators were unable to profitably operate the A380s and seldom realised its promoted green credentials unless it had high load factors.

A similar trend is occurring where the newer derivates of narrow-body aircrafts such as the Airbus A320neo, A321LRneo and A321XLRneo and Boeing 737Max (currently grounded) are either replacing or supplementing wide-body twin engine aircraft on medium haul routes of up to 8,700 km. The appeal of narrow-body aircraft is that they can operate out of narrower and shorter runways and require fewer crew members in-cabin compared to wide body aircrafts, making them relatively more profitable to operate whilst growing market share and/or increasing frequencies on trunk routes.

Debbage and Debbage (2019) show that direct non-stop travel on mid-sized twin engine jets produce lower emissions than hub-and-spoke routes, although the extent of the savings between a non-stop route and the next best option was equivalent to turning off a refrigerator for one year. Philippine Airlines commenced non-stop Manila-Brisbane services in July 2018, replacing the triangulated service via Sydney, Melbourne or Darwin. Instead the larger A330-300 now serves the Manila-Sydney route and the A321neo is used for the Manila-Brisbane city pair. An overall increase in frequencies resulted, leading to more emissions despite each sector being relatively more fuel efficient.

In most cases, replacement fleet with fuel efficient aircrafts are welcomed news. Jetstar will replace its Airbus A321 with the newer A321LRneo with greater payload, range and approximately 15% saving in fuel. Such like for like replacements with similar frequency of flights will lead to emissions reductions relative to status quo. In Jetstar's case, the benefit is equivalent to removing 1,500 cars off the road. While this constitutes an environmental improvement, the greater benefit is higher profits by having significantly increased payload and range. This in turn, could stimulate further expansion by the airline company, leading to more emissions (the classic rebound effect).

TABLE 6. QUANTIFIED ANNUAL CO_2 REDUCTIONS THAT FOCUSED ON AIRCRAFT EFFICIENCY, AS REPORTED BY AIRLINES

EFFICIENCY	MAINTENANCE	WEIGHT REDUCTION
Winglets: • 700,000 tCO_2 (American Airlines) • 26,317 tCO_2 (Southwest Airlines) • 120,000 tCO_2 (China Eastern Airlines) • 43,065 tCO_2 (Alaska Airlines)	Enhanced wash to restore engine performance: • 3,191 tCO_2 (Qatar Airways) • 26,405 tCO_2 (Singapore Airlines) • 16,000 t of CO_2 (Norwegian Air Shuttle) • 15,200 tCO_2 (Asiana Airlines) • 14,026 tCO_2 (Xiamen Airlines)	Lightweight equipment: • Crew equipment: 900 tCO_2 (Hainan Airlines) • Baggage and cargo container: 8,006 tCO_2 (Eva Air) • Cabin carpets and lightweight containers: 2,600 tCO_2 (Scandinavian Airline Systems-SAS)
Fuel efficiency management program of policy: • 60,000 tCO_2 (Air France) • 68,200 tCO_2 (Hainan Airlines) • 2,236 tCO_2 (Eva Air) • 34,650 tCO_2 (Cathay Pacific) • 100,000 tCO_2 (Wizz Air)	Carbon brakes on aircrafts saving 2,734 tCO_2, and technical aircraft maintenance saved 4,695 tCO_2 (Turkish Airlines)	Rightsizing provisions to reduce operational weight: • 3,200 tCO_2 (Delta Airlines) • 2,306 tCO_2 (Southwest Airlines) • 13,500 tCO_2 (KLM)
Minimum fuel over spill, avoiding 900 tCO_2 (Asiana Airlines)		Water load management: • 6,312 tCO_2 (Singapore Airlines) • 2,391 tCO_2 (Asiana Airlines)
		Payload weight accuracy improvements: • 6,700 tCO_2 (Asiana Airlines)
		Optimizing the use of fuel when planning alternate landing sites: • 2,871 tCO_2 (Alaska Airlines) • 40,338 tCO_2 (Qatar Airways)
		Paperless cockpit: • 3,828 tCO_2 (American Airlines) • 93 tCO_2 (Southwest Airlines)

5.3.2 Operations

Another area of avoiding CO_2 emissions relates to routes, descent management and tools to guide pilot decision making (Table 7). As an example, Lufthansa uses OMEGA software for real-time pilot updates, to enable better decision making for identifying efficient routes, with savings of 26,937 tonnes of CO_2 in one year. This is equivalent to 0.09% of the Lufthansa Group's emissions. Key initiatives are:

- Route optimisation in response to weather conditions (e.g. to take advantage of tailwinds or to minimize headwinds).
- Optimising use of airspace.
- Optimising approaches and descent and collaborating better with air traffic control.
- Software supported real time updates, including through the use of big data.

Qantas

Qantas is deploying FlightPulse which uses smart analytics and millions of data points recorded on aircraft, allowing pilots to see the amount of fuel used at different stages of a flight and how they can help reduce carbon emissions. In addition, pilots use User Preferred Routing (UPR) and dynamic airborne re-route procedures (DARP) to optimize route while in-flight.

TABLE 7. QUANTIFIED ANNUAL CO_2 REDUCTIONS AS REPORTED BY AIRLINES WITH A FOCUS ON FLIGHT ROUTE AND AIRSPACE

ROUTE OPTIMISATION / NAVIGATION / WEATHER ETC	LOT CYCLE IMPROVEMENTS	IN FLIGHT ROUTE ADJUSTMENTS; PILOTS DECISIONS, NEW SOFTWARE
Optimisation of routes: • 12,477 tCO_2 (Qatar Airways) • 4,500 tCO_2 (KLM) • 13,100 tCO_2 (IndiGo Airlines) • 18,649 tCO_2 (Eva Air)	Idle reverse thrust on landing, saving: • 15,564 tCO_2 (Emirates)	The OMEGA software displays historical flight routings in flight on pilots' electronic maps, allowing them to identify shortcuts and to plan more efficient approaches Annual savings: 26,937 tCO_2 (Lufthansa)
Beijing-San Francisco Green Route Optimization Program: • 1,402 tCO_2 (Air China)	Collaboration with air traffic control providers (descent and approach profiles): • 2,577 tCO_2 (Etihad)	Real time optimised routes (flying the best wind routes): • 122,247 tCO_2 (Southwest Airlines) • 5,260 tCO_2 (Hainan Airlines)
"Green flight" Completing 32,571 flights shortening the flight distance by 1,755 million km: 21,105 tCO_2 (China Eastern)	Alternate airport selection saving: • 6,608 tCO_2 (Alaska Airlines)	Aircraft drag reduction procedures: • 9,400 tCO_2 (Asiana Airlines)
Optimised route from Beijing to Manzhouli via Mongolian airspace shortened travel distance by 159 km: 2,630 tCO_2 (Hainan Airlines)	Air Traffic Control improvements (better forecasting of flight time): reductions of around 184 tCO_2 per year (Air France)	Global Dispatch Network (GDN): • 41,044 tCO_2 (Swiss)
Optimising flight operations: • 103,735 tCO_2 (Xiamen Airlines) • 21,300 tCO_2 (Asiana Airlines) • (eg 4-D planning) 141,186 tCO_2 (Turkish Airlines) • 28,500 t of CO_2 (Asiana Airlines)	Upgrades to arrival paths at Phoenix and Washington airports: • 11,000 tCO_2 (American Airlines)	Required Navigation Performance uses a combination of onboard navigation technology and the GPS satellite network: • 11,484 tCO_2 (Alaska Airlines)
Flight plan adjustments across the network: • 17,000 tCO_2 (Etihad)		

Few airlines also report on reducing carbon in their office buildings and ground transport. Compared with aviation fuel emissions savings are miniscule. However, they are still important, especially when they generate co benefits. Cathay Pacific's investment into 20 electric vehicle chargers, for example, contributes to improving air quality in Hong Kong.

Some airlines quantified savings in relation to ground-based initiatives, such as the use of Auxiliary Power Unit (APU) electricity at the gate, but these were usually relatively small in the order of a few thousand tonnes of CO_2 reduced. For example:

- APU usage by Air New Zealand saved 6,300 t of CO_2, and APU savings reported by Eva Air amounted to 4,306 t of CO_2.
- Single engine taxi after landing saved 3,686 t of CO_2 for Emirates and 5,000 t of CO_2 for Iberia.

China Southern Airlines

With the goal of improving the management of fuel data, China Southern Airlines developed the "Fuel e-Cloud" data platform which can realise the real-time monitoring and accurate prediction of fuel consumption. On May 24, 2018, the "Fuel e-Cloud" data platform of China Southern was connected with the ERP system of China National Aviation Fuel, which can realise the rapid acquisition of refueling data for more than 80% of China Southern's domestic flights and support the management of fuels which in turn reduces aircraft operating costs.

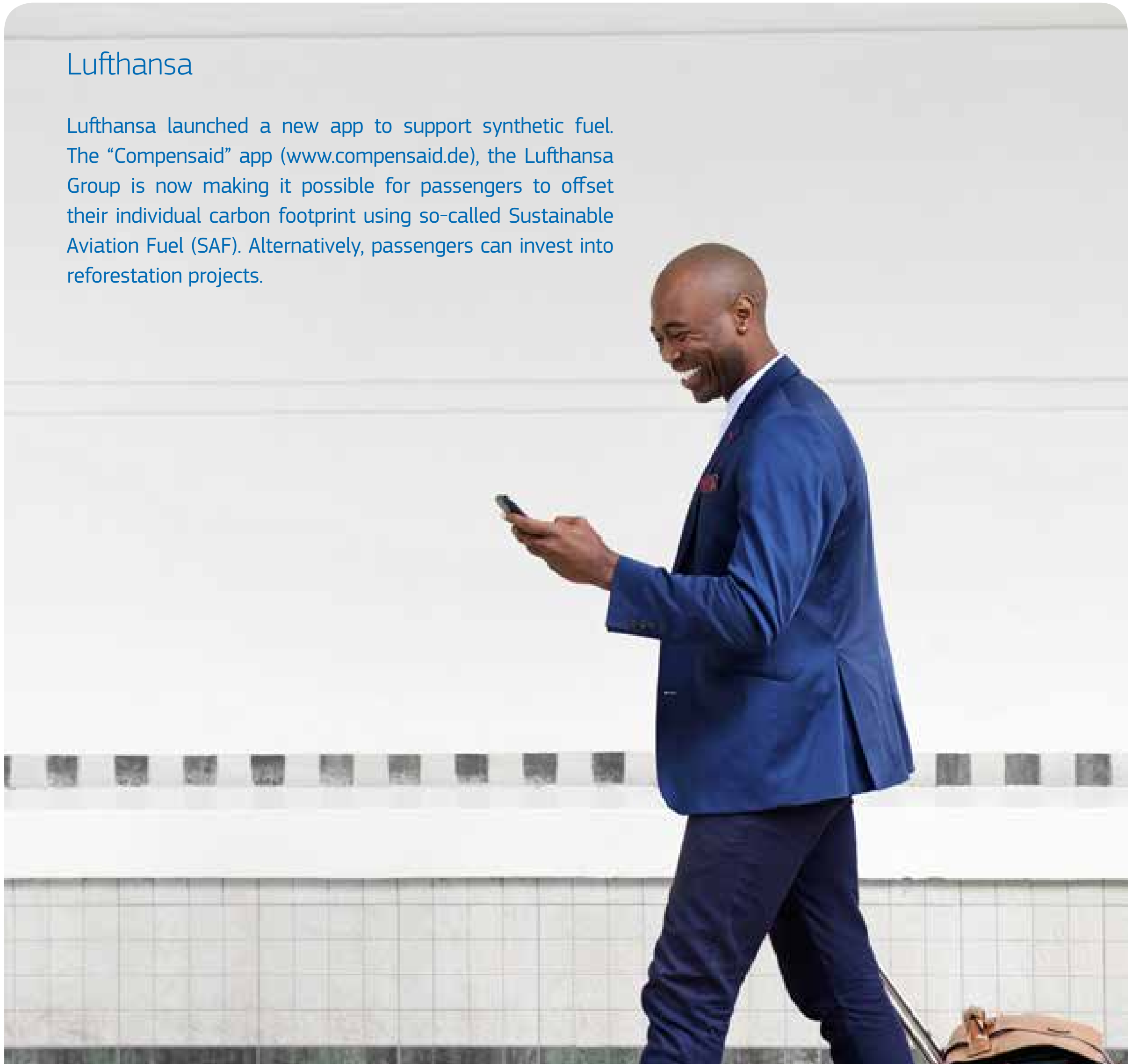
5.3.3 Biofuel and alternative fuels

Nineteen airlines reported on investing into biofuel through some form of partnership. Some were more specific and advanced than others. United Airlines, for example, has invested $30 million in US-based alternative fuels developer Fulcrum BioEnergy. In the meantime, the airline has purchased over 2 million gallons of biofuel at Los Angeles Airport in the first two years of AltAir Fuels' operation.

Several airlines have teamed up with universities and other research partners to explore the life cycle of biofuels or other aspects of commercialisation of feedstock (e.g. Delta, KLM and Qatar). Other airlines have been an active partner in trials that involved airports and Federal funding agencies. Air Canada is collaborating with the Canadian government and industry stakeholders as part of the Natural Resources Canada (NRCan) "Sky's the Limit Challenge". The Challenge is federally funded and is intended to incentivise innovation for sustainable aviation fuel in Canada.

Lufthansa

Lufthansa launched a new app to support synthetic fuel. The "Compensaid" app (www.compensaid.de), the Lufthansa Group is now making it possible for passengers to offset their individual carbon footprint using so-called Sustainable Aviation Fuel (SAF). Alternatively, passengers can invest into reforestation projects.



At this point, most biofuel activities appear to be at a trial stage or represent one-off opportunities. For example, using a combination of Hydro-processed Esters and Fatty Acids produced from used cooking oils and conventional jet fuel, Singapore Airlines operated 12 "Green Package" flights to San Francisco over a three-month period from May 2017 (SIN-SFO). Carbon savings for a single Air Canada flight were about 27 tonnes of CO_2 blended biofuel as part of a campaign on Earth Day. Cathay Pacific reported that delivery flights of new Airbus A350-900 aircraft were operated with blended biofuel. This consumed 159 tonnes of biofuel.

Only four airlines mention electric aircraft in their carbon reduction strategies. Most provide no detail on this important avenue of carbon reduction. Only EasyJet is a little more specific in their reporting in that they refer to a partnership with Wright Electric that began in 2017 to support the goal for short-haul flights to be operated by all-electric planes.

British Airways

In October 2019, British Airways announced that it will offset all domestic flight emissions from 2020. IAG – of which BA forms part – was the first airline group to commit to net-zero carbon flying by 2050. Recognising that electric or hydrogen aircraft are not a realistic substitute for international flights, the goal would be achieved through offsetting, sustainable fuels and fleet renewal. BA has pledged to invest £327m in sustainable fuel over the next 20 years. This includes a joint venture to build a waste-to-jet fuel plant in the UK. The announced cost of offsetting British flights (about 400,000 tonnes of CO_2), is about €3.2m (£3m) in 2020. The carbon price underpinning this assumption is £7.5 – representing a lower end estimate of costs that are likely to increase in the future.

Virgin Atlantic

Virgin Atlantic is investing into a partnership with LanzaTech to make fuels by recycling carbon from industrial waste gases and other unavoidable waste streams. The airline claims that this particular fuel is saving over 70% across the product's carbon life cycle compared to fossil jet fuel. Fuel volumes could be made commercially viable and comparable to fossil fuel prices by 2021. The total available volume is quantified ad 125 million gallons. The key feedstock is municipal solid waste (MSW). In terms of impact, Virgin Atlantic estimates that this would be sufficient to fly all current UK outbound flights (at a 50:50 mix with fossil jet fuel) and avoiding one million tonnes of life cycle carbon per year.

WILL USE OF BIOFUELS REDUCE CO_2 EMISSIONS?

There is a general belief that biofuel is 'carbon neutral', because carbon released into the atmosphere will be reabsorbed when organic materials regrow. This common assumption is unhelpfully enshrined in current biofuel guidelines, for example in the European Union or the USA (Booth, 2018).

In reality, there are several substantial oversights in this logic (German et al., 2011), leading DeCicco (2016) to conclude that the role of biofuel is much more limited than thought, and potentially "worse than the disease" (p. 5). Assessing the merits of biofuel is complex because feedstocks are extremely varied, ranging from crops (e.g. corn, oil palms), to forest residues and industrial waste (e.g. oils, landfill waste).

However, as a rule, combustion of one litre of biofuel releases CO_2 into the atmosphere, just like burning fossil-fuel. It constitutes a 'pulse' of CO_2 that increases concentrations of CO_2. There are three related but distinct challenges.

Carbon intensity. To produce biofuel we need energy, whereby the Energy returned on Energy invested (EROEI) is much lower than for fossil fuel. Typically, biofuels are assessed using lifecycle analysis (LCA). Measuring the carbon intensity of biofuel generally considers emissions from growing the feedstock, transporting the material to the factory and processing it into fuel. These are deducted from the absorption of CO_2 emissions from growing the organic material. A recent study on USA corn ethanol, for example, estimated that the biofuel's GHG profile is 39–43% lower than fossil fuel (Lewandrowski et al., 2019).

'Baseline effect'. LCAs do not consider land use changes or other 'baseline effects'. Burning biofuel results in complete release of the carbon in the form of CO_2. Instead, for example, the decay of forest residue in its natural environment will not release all carbon. Much of it, for example, will be stored in the soil or might be absorbed in sediment in lakes or the ocean. Thus, for there to be a gain it is important that the use of a product as biofuel does not increase carbon emissions in the atmosphere relative to its "alternative fate" (Booth, 2018). DeCicco (2016) analysed the net effect of biofuel production in the USA, finding that biofuel land use increased CO_2 emissions compared with previous uses.

Time lags. Biofuel is a 'slow in – fast out' problem as often sequestration will occur over longer period of times. This problem is particularly prominent in cases where land (and associated carbon sinks) has specifically been cleared for biofuel (e.g. the case of palm oil plantations in Indonesia when primary rainforest is cleared). Such land use change can result in significant carbon debts. For the case of soybean, it may take between 18 and 41 years until net positive climate effects are achieved. For palm oil, the debt ranges between 34 to 85 years (German et al., 2011). A similar effect has been discussed for biofuel from waste. Attempts in Australia to turn plastic into fuel have been critiqued by scientists because combustion as fuel releases carbon immediately, whereas plastic in a landfill takes many centuries to decay (Opray, 2016). Considering that carbon emissions need to reduce rapidly within the next 8 years, such options may not deliver adequate solutions.

5.3.4 Carbon offsetting

Offering carbon offsetting programs is increasingly popular amongst airlines, although reporting on implementation is still rudimentary. The assessment of 58 airlines showed that:

28
airlines make reference to carbon offsetting in some form

9
airlines provide information on uptake by customers

13
airlines attempt to quantify the impact of their offsetting activities

Tangible information on uptake and volume of credits is limited, and where available, indicates very low numbers. The marginal impact that offsetting programs are making have also been reported in a BBC-led assessment of airlines earlier in 2019, where it was estimated that only about 1% of travellers offset their emissions (Lee & Foster, 2019). The numbers identified here also do not appear to demonstrate much improvement compared with an earlier assessment of airline offsetting in 2016 (Becken & Mackey, 2017).

The following Table 8 summarises information on carbon offsetting available from reports. It can be seen that limited details are shared and there is no consistent way of reporting mitigation success through offsetting. In some cases, it was unclear whether numbers referred to the last year of reporting or were cumulative.

Whilst some airlines are increasing their efforts in offering credible carbon offsetting programs to concerned customers, there is also a growing sentiment against carbon offsets. A recent report by Doyle (2019) from the London School of Economics on aviation emissions and offsets is backed by a group of institutional investors, sending a clear message that airlines need to have more robust long-term plans that do not rely on controversial offsetting.

TABLE 8. CARBON OFFSETTING INFORMATION PROVIDED BY AIRLINES

AIRLINE	DETAIL	CONTEXT OF EMISSIONS
AVIANCA	In 2018, the airline offset the impact of the emissions generated by operations in Colombia. Total: 1,019,170 tCO_2.	Equivalent to 20.41% of the Holding's total Scope 1 emissions.
DELTA	Since 2013, Delta has purchased and retired nearly 9 million carbon offsets. The airline has a commitment to retire nearly 3 million offsets for their 2018 growth compared to 2012 levels.	Annual emissions were 37 $MtCO_2$; the offset suggests a coverage of 8%.
JETBLUE	The airline offset the CO_2 emissions for all customers (> 3 million) flying in June 2019. Estimate: 700,000 tCO_2.	Emissions were 7.8 Mt; the offset represents 9.0%.
QANTAS	Customers offset their flight every 59 seconds. Since launch of the program in 2007 the airline has offset over 18 million tCO_2.	Qantas emits 12 Mt annually.
VIRGIN AUSTRALIA	Over 4 million seats and 500,000 tCO_2 offset since inception in 2011.	2017/18 emissions were 3 Mt.
CATHAY PACIFIC	Customers offset 150,700 tCO_2 since 2007. In 2017 they airline offset 13,697 tCO_2.	The 2017 emissions were 18 Mt; offsets represent 0.2%.
KLM	60,000 passengers reduced their flight footprint by offsetting over 29,000 tCO_2.	KLM's emissions were 28 Mt; the offsets represent 0.1%.
BRITISH AIRWAYS	Supported over 37 projects, impacting the lives of 250,000 people and resulting in community benefits of over £2 million.	No comparison possible.
SAS	The offsetting program covers almost 4% of the airlines' passenger CO_2 emissions. In April, the airline began providing offsetting for all youth travel. Total: 135,000 tCO_2.	Youth offsets represent 3.1% of annual emissions.
AIR NEW ZELAND	130,000 journeys in 2017.	No comparison possible.
NORWEGIAN	Launched "Plant for the Planet", planting 9,500 trees in the UK and Spain - one for every person working at the company. In addition, tens of thousands of trees were planted in other parts of the world.	No comparison possible.
VIRGIN ATLANTIC	Cooking Stoves project found over 24 million homes and saved approximately USD 40 million worth of charcoal use in Ghana.	2017/18 emissions were 4 Mt. No comparison possible.
VIRGIN AMERICA	In 2017, customers offset 222 t of CO_2e. Collectively, the airline has offset 8,138 tons of CO_2e since 2013. In 2017, Virgin America offset its corporate headquarters' annual footprint plus an additional 1,000 tonnes as part of Earth Day.	Now part of Alaska Airlines.
EVA AIR	Since May 2017 (when it went live) 4,303 tCO_2e had been offset, equivalent of the amount absorbed by 3,586 trees in a year.	Offsets represent 0.07% of 2017 emissions.

↑ At the time of closing this report, easyjet has announced it will offset 100% of its total emissions, joining Swedish regional carrier Braathens in their initiative to offset total emissions from flights.

Air New Zealand

Recognising the co-benefits of carbon sequestration through forest sinks, Air New Zealand is investing into six native forest regeneration projects in New Zealand. The FlyNeutral programme purchases carbon credits registered with the New Zealand Government under the Permanent Forest Sink Initiative. For more information see here: https://climatecare.org/carbon-reduction-projects-supported-by-the-air-new-zealand-carbon-offset-programme/

The Chatham Islands Forest Restoration Project is located on Owenga Station, a 4,000-hectare sheep and cattle farm on Chatham Island. The project represents an outstanding contribution to the recovery of indigenous forest on the Chatham Islands.

IS CARBON OFFSETTING A SOLUTION?

Carbon offsetting is often discussed in the context of aviation emissions, because it provides a short-term option to mitigate GHG emissions. CORSIA relies on the concept of carbon offsets to achieve 'carbon neutral growth', and several airlines offer offsetting schemes to their business partners or customers to help them address the climate impact of their travel.

Offsets have been criticised because they will not 'decarbonise' transport, but the decarbonisation is outsourced to another sector or actor. This results in a 'zero sum effect' whereby no absolute reduction occurs in terms of atmospheric carbon concentrations. However, offsetting can slow down the rate at which anthropogenic CO_2 is emitted into the atmosphere, and it can also help 'repay' the carbon debt from previous deforestation in the case of forest sinks. Net reductions can occur, however, if two offsets are purchased to compensate for 1 tonne of carbon (i.e. one to 'neutralise' and one to achieve a net gain).

In the short term, offsetting can provide important funds towards mitigation activities in those parts of the economy that can reduce emissions at the lowest cost and are most scalable (Becken & Mackey, 2017). Ensuring the integrity of carbon offsets is critical (real, additional, verifiable, not double counted and permanent emission reductions), and quality offset schemes can provide benefits so long as their true mitigation value is not misrepresented.

Recent work for the UK Department for Transport (Lee, 2018) highlighted that CORSIA offers an intermediate contribution, but will not be enough to address the aviation industry's emission reduction needs. The Paris Agreement requires working towards zero emissions for all sectors, and an exclusive offsetting approach is not compatible with that goal.

Given the complexity around offsets, it is important to foremost inform people about the impact of their transport decision with the aim to:

- Consider what journeys are essential and could be avoided in the future.
- Choose the comparatively most carbon friendly option (per destination option).
- Offset as a last resort and make a useful contribution to climate mitigation, but not under the illusion that one's emissions are negated.

6 Conclusion and recommendations

6.1 Growth meets resistance

A growing world economy coupled with decreasing airfares has led to faster-than average growth of the aviation industry compared with the world economy. Corresponding with this growth is an increase in CO_2 emissions. The International Coalition for Sustainable Aviation (2018) reported that aviation emissions had increased by 32% over the past five years; that is 70% higher than the ICAO projections foresaw for that time. In terms of the urgent need to reduce global GHG emissions drastically to remain within a limit of 1.5 or 2.0 degrees Celsius warming, the increasing aviation emissions pose a significant challenge.

There is mounting evidence that climate change has accelerated with impacts materialising faster and at a greater magnitude than previously projected. Examples include faster-than expected polar melting, thawing of permafrost and increased rates of sea level rise. Scientific findings resonate with growing concern amongst the public, in particular the youth. More governments are considering including aviation into climate change policies, in addition to existing mechanisms (e.g. CORSIA) that are believed to be inadequate in curbing aviation emissions. Whilst taxing flights is one option, some consumers are beginning to 'vote with their feet'. The phenomenon of flygskam/flightshame is discussed globally and appears to have led to some reductions in demand in Sweden. Governments, companies and education organisations are beginning to set targets for reducing emissions from air travel. The question whether travel is necessary or dispensable is being discussed more openly and more people are considering the trade-offs of their travel (Gössling et al., 2019).

This report highlighted that more than half of the leading airlines are reporting on their efforts to reduce GHG emissions. Surprisingly, there are still many airlines in advanced economies and growing economies who do not disclose emissions or carbon reduction initiatives. For those that do, a very broad range of reduction opportunities could be identified, although the yard-stick measurements are not standardised to enable meaningful comparisons. In some cases, it is difficult to assess the materiality and impact of changes made and reported. It is not surprising, that airlines attract considerable criticism and scepticism regarding their environmental credentials. Brian Sumers from Skift (2019) recently wrote critically about the increasing awareness of "airlines as polluters" that some have argued is also used as a smokescreen to further the economic and profitable interests of airlines and its shareholders.

Indeed, both consumers and other airlines have called out the practices of offering extremely cheap fares. Scandinavian Airlines – positioning itself generally as an environmental leader amongst airlines – has been criticised for selling fares under $300 between some U.S. and European cities. Regarding special discounts offered by Ryanair (e.g. 10 euro flights) led Lufthansa's CEO to state that such fares are "economically, ecologically and politically irresponsible."

6.2 Carbon reduction efforts

The two most prominent areas for reducing emissions relate to aircraft efficiency and flight path management. To improve efficiency, airlines invest in new fleets, install fuel saving devices (e.g. winglets), improve the maintenance of their engines, and reduce weight. For improvements in operating flights, airlines invest into big data driven navigation and flight path forecasting systems, and they also partner with air traffic control systems or airports to optimise flight paths. Some measures result in greater savings than others, and some airlines report on a considerable number of individual initiatives that lead to a substantial improvement.

However, the analysis also revealed that none of the reported measures alone can reduce emissions significantly. With initiatives leading to savings in the order of 0.1 or at best 0.3% of annual fuel use, an airline would have to implement about 20 such measures (each year) to compensate for growth in emissions. Indeed, the analysis of 35 airlines showed that whilst most were able to demonstrate improvements in efficiency per available seat kilometre, all of them saw substantial growth in total emissions. Thus, the report clearly shows that the incremental improvements, whilst valuable and indispensable, will not help the industry address its growing carbon footprint and contribution to global emissions.

A small number of airlines invest into alternative fuels, in particular biofuel. Electric planes and related investments appear marginal at this point. Alternative technologies and fuels face considerable challenges. For biofuel, there are substantial barriers in the form of cost and availability (in particular at high volumes). In addition, research into the carbon cycle and the net benefits of biofuel shows that many feedstocks are unlikely to generate a benefit. Potentially, the use of biofuels could lead to higher emissions compared with simply burning fossil fuel.

About half of the top airlines engage in some form of carbon offsetting. Similar to biofuel, there are challenges in that supply of high-quality credits is limited and uncertain. Moreover, the purchase of offsets does not decarbonise aviation and fails to deliver real reductions. However, whilst carbon offsetting might not provide a long-term and definite solution, it is an important transition mechanism that helps travellers and businesses contribute to positive climate action for those emissions that cannot be avoided, at least in the short term and when high quality schemes are chosen. Airlines still have to improve the delivery of their carbon offsetting programmes to secure customer uptake and measurable impact. At this point, offsetting is in the order of a few percent, at best.

Some airlines have begun to offer their passengers an opportunity to invest into either alternative fuels or offsets. This may help increase awareness amongst travellers and give people the feeling that they are doing something. It also helps raise funds for projects that at this present point can deliver carbon reductions at a cheaper cost than aviation. Clearly, though, funds provided by travellers are not enough to develop new technology that is needed to rapidly reduce emissions.

6.3 The role of governments

Governments have a role in that they can accelerate investment into Research & Development. Technology in particular, is probably underestimated as a way to reconcile travel needs and sustainability, both in the short and long terms. Some technology solutions currently available that help reduce impact, for example those related to collaborative decision making at airports are far from being used to their full potential. Improving air traffic management involves a range of partners and technology needs to be accompanied with supportive behaviour change programs to build collaboration (e.g. air traffic controllers, airlines, pilots etc.).

Synthetic aviation fuels might be another answer; noting that the production costs are much higher compared with traditional kerosene-based fuel and this will likely reduce demand over time. To assess the impact on demand of (much) higher carbon prices it is recommended to engage more in scenario analyses and modelling. Models that specify maximum temperatures (e.g. 1.5 degrees) and calculate the cost of reaching these arrive at estimates of carbon prices in the order of $229 per tonne of CO_2 in 2030 and $1,006 by 2050 (Boyce, 2018).

Over the longer term we count on three positive factors that may encourage further efforts and success in research and development. Firstly, the number of highly qualified technology workers is larger than ever, knowledge is shared with unprecedented ease and the financing of projects has become, on average, more accessible than ever before. Innovations like electrical aircraft where unthinkable only a few years ago and it is reasonable to expect further significant developments in the future. Concerted efforts and collaboration, however, will be key to realise some of these opportunities.

In the meantime, there are other ways governments can support the aviation industry. For example, they may also provide positive signals to help airlines write off old and inefficient aircraft relatively sooner. Carbon leakage to lesser regulated countries must be avoided. There might also be a role for the public sector to invest into research that helps airlines, and the travel and tourism industries that depend on them, understand better the risks that climate change imposes on their current business models. Future analyses and planning, including those that consider significant shift in demand, would help in informing decision making on new aircraft investments, route networks, and new technologies. Recent analysis by Becken and Carmigagni (2019), for example, provides alternative aviation demand paths that – regardless of the scenario – all show lower growth rates than frequently used industry forecasts.

At the level of international agreements, Lyle (2017) has argued that meaningful reductions in aviation emissions are more likely to be achieved by bringing international aviation into the Nationally Determined Contributions of parties to the Paris Agreement. The United Kingdom and the European Union are currently exploring such an option. Whilst annulling CORSIA exclusivity, such shift could encourage rather than proscribe stronger national action. It would also enable better integration with domestic policies, as well as mitigation measures for airports, surface travel and other related sectors.

6.4 Transport networks and access

Governments have begun to intervene more deliberately into transport networks and consumer incentives. The recent “Klimapaket” by the German Government, for example, increases the existing tax on aviation to raise revenue for then reducing the Goods and Service Tax on rail travel. Working on better integrated transport systems, with low carbon option, should be a priority for countries committed to reducing their GHG emissions.

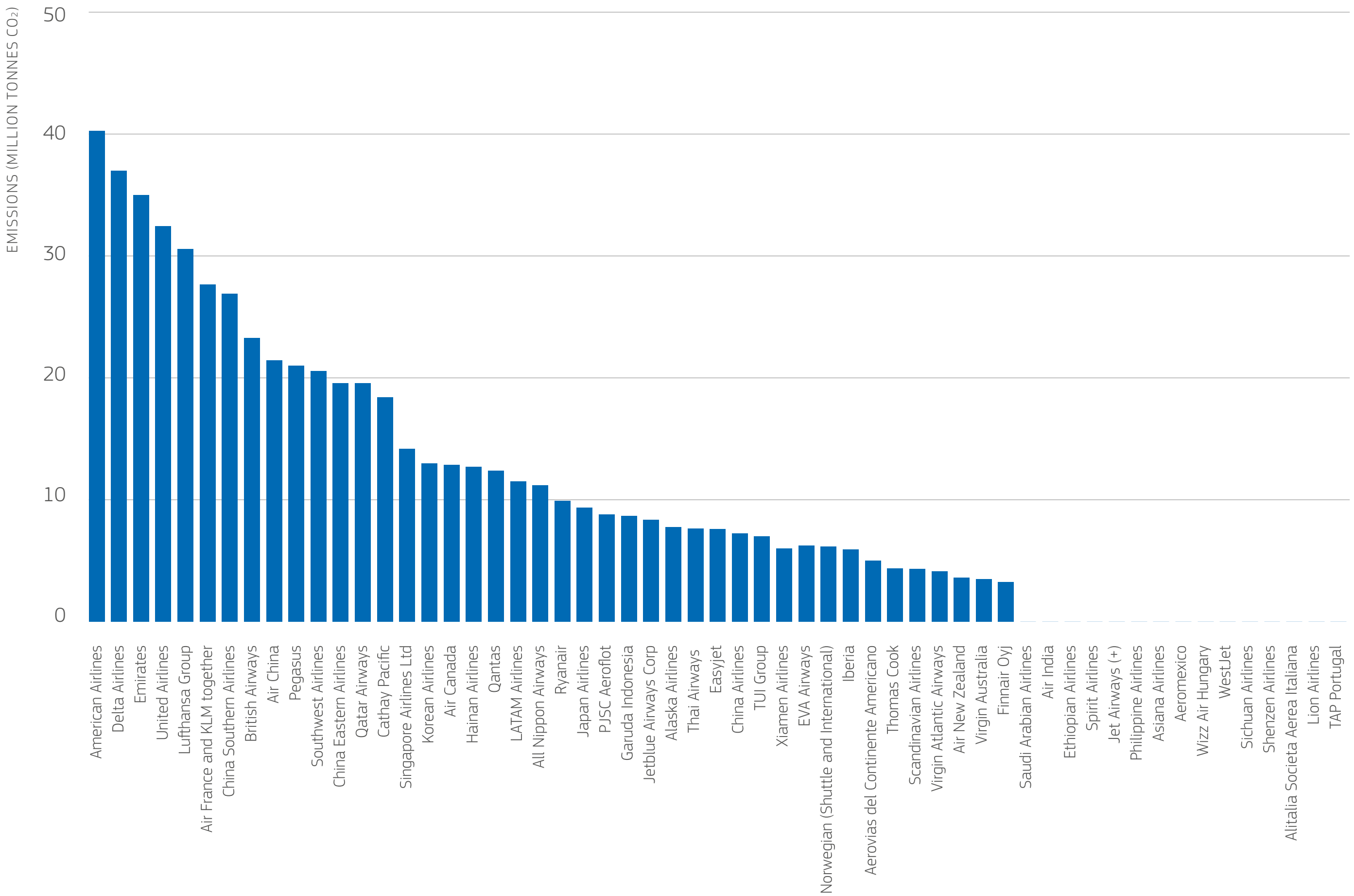
Moving passengers onto rail may not necessarily be to the detriment of airlines, especially when these partner (or buy into) rail companies. As early as 1981, Lufthansa started to work with Deutsche Bahn to deliver rail links from Cologne and Duesseldorf (to Frankfurt), all equipped with Lufthansa branded seats and a flight number. A wide range of countries now operate similar models. Air France, for example, now offers its Strasbourg – Paris link via high speed rail, allowing customers to check in at Strasbourg, including the option for connecting to other flights. Offering passengers convenient one-stop-ticketing services for inter-modality is becoming more prevalent.

Providing access or mobility is the core purpose of airlines. In its present form this comes at a considerable carbon footprint. In the future, airlines may well find other opportunities for delivering their role, for example through advanced tele-communication or virtual experiences. All Nippon Airlines, for example, is already investing into virtual reality as one way of extending its current business model beyond solely providing flights. More creative thinking will be required to lead airlines out of the conundrum of growing emissions and increasing pressure to reduce them.

7

Appendix

FIGURE 10. CO_2 EMISSIONS IN 2017/18 REPORTED BY 40 AIRLINES



↑ Note that United, Emirates, Air China, Pegasus Airlines, Korean Airlines, Xiamen Airlines, Finnair and Thomas Cook emissions refer to 2016/17 – the latest year available in those airlines' reporting.

8

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