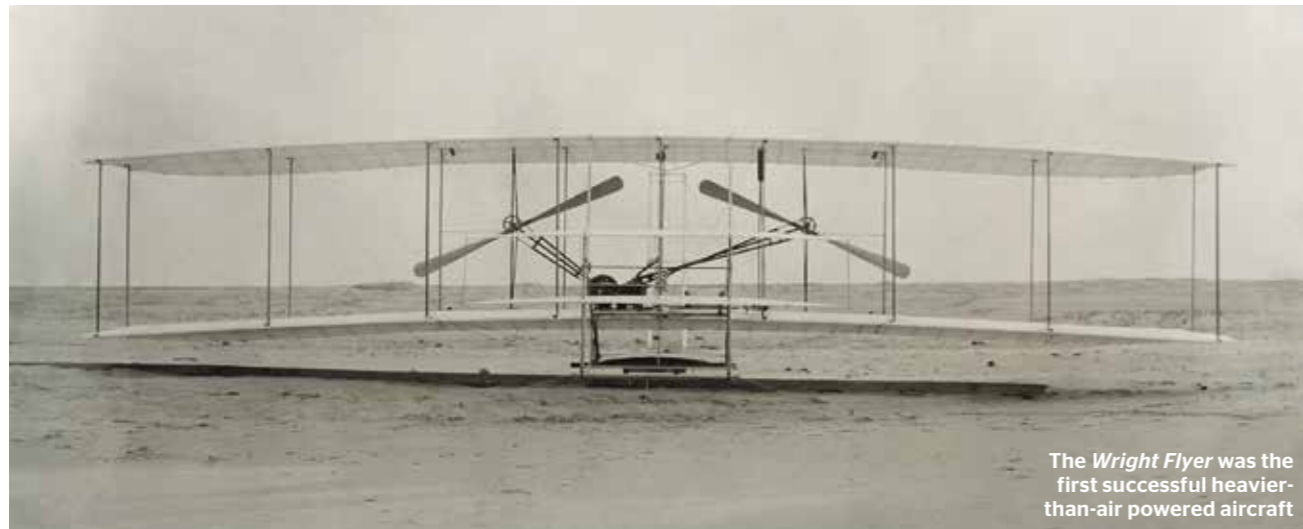




# HEAD IN THE CLOUDS

Large-scale air travel is under public scrutiny, and refusing to fly is increasingly in vogue. Can climate-friendly aviation ever actually exist? If not, can not dismantling the industry really be justified?

by Chris Fitch



The Wright Flyer was the first successful heavier-than-air powered aircraft

EVERETT HISTORICAL

**A**t 10.35am on a windy morning on 17 December 1903, a wobbly contraption constructed from wood and cloth accelerated along a beach in North Carolina. Inexplicably for most observers, it lifted into the air. For the next dozen seconds, the machine maintained an altitude of around 20 feet – precarious, but undeniably airborne – before descending and coming to rest 120 feet from where it had taken off. For the first time in human history, the dream of powered flight had been achieved. Orville Wright’s pioneering journey as pilot of the *Wright Flyer* ushered in a new age in human mobility. But surely it was beyond the imagination of even the Wright brothers to envisage a world in which more than 200,000 planes would fill the skies above our heads on any single day, a threshold that was broken in 2018. From what was essentially a long hop across the ground, Qantas recently tested the world’s new longest flight, an incredible 16,200km (10,066-mile) journey stretching all the way from New York to Sydney.

Air freight – from perishable foods to vital medicines – is relatively small in terms of volume, but highly valuable to the global economy, with 64 million tonnes of cargo transported annually by aircraft. From trade to tourism, finance to football, it’s hard to grasp the many ways in which cheap and fast aviation has transformed the modern world, enabling a truly global economy to emerge.

Yet while the industry continues to boom, dark clouds are gathering on the horizon in the form of aviation’s persistent and increasingly large carbon footprint. While by no means the instigator, perhaps to be considered at the centre of this particular storm is Swedish activist Greta Thunberg, who has become a figurehead for the ‘no-fly’ movement. In Thunberg’s native Sweden, *flygskam* (flight shaming) has become a popular buzzword, where those who choose to keep both feet on the ground stigmatise those who

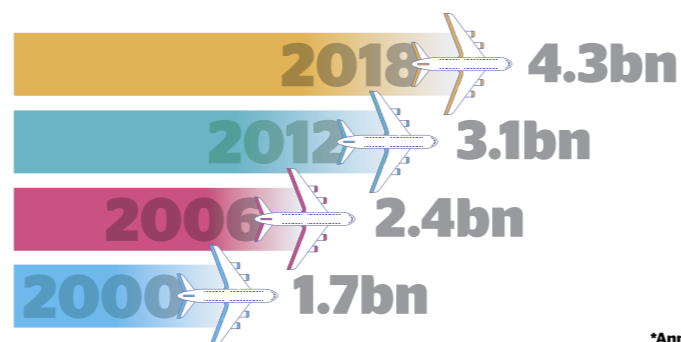
opt for journeys by aircraft (a rival word, *smygflyga*, describes the process of flying in secret). Worryingly for the aviation industry, it is a trend that appears to be slipping across borders, with thousands in the UK, Germany, the US and others pledging to be ‘flight free’ in 2020.

So where does this leave aviation? While car manufacturers turn to electric vehicles and fast food establishments whip up their trendy new vegan menus, what can the likes of Boeing and Airbus – not to mention the many airlines who actually purchase these enormous aircraft – do to prevent themselves becoming lumbering dinosaurs caught in the headlights of public demand for a reduction in their emissions in the face of looming climate change? Could climate-friendly aviation ever become a reality? If not, what are the options available for consumers who wish to sidestep aviation? Ultimately, in a climate-constrained future, can we justify not dismantling aviation altogether?

#### THE PROBLEM

Worldwide aviation released 905 million tonnes of carbon dioxide into the atmosphere in 2018, according to figures published by the International Air Transport Association (IATA), the trade group for nearly 300 airlines. This is around two per cent of the 42 billion tonnes emitted from anthropogenic sources annually. ‘The contribution of aviation to climate change is quite small,’ explains Paul Williams, a professor of

#### WORLDWIDE AIR PASSENGER NUMBERS\*



\*Annually  
(Source: IATA Annual Review 2019)



Airline passenger numbers are expected to reach more than eight billion annually by 2040

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atmospheric science in the Department of Meteorology at the University of Reading, ‘but of course it’s growing rapidly and it’s finding it hard to decarbonise. We expect rapid growth, and that is a problem.’

More than 4.3 billion passengers took to the skies in 2018 (more than a doubling of numbers since the turn of the millennium) travelling along some 22,000 routes around the world. IATA figures predict this will balloon to 8.2 billion annually over the next 20 years. The environmental impact of this growth will be dramatic, with the carbon emissions from international aviation growing from around 500 million tonnes in 2015, to nearly 2,000 tonnes by 2050 in a worst-case scenario. While various mitigation schemes hope to significantly stymie this growth, even the best case outcomes see more than a doubling by the middle of the century. ‘At the moment, the rate of growth and the amount that we’re using it is incompatible with the goals laid out in the Paris Agreement in the next two to three decades,’ says Alice Larkin, a professor of climate science and energy policy at the University of Manchester.

Of course, planes are far from the first symbol of modern life to find themselves on the wrong side of history with regards to their reliance on fossil fuels. But air travel has found it more difficult than most to shift away from this addiction. ‘Whereas other sectors of the economy are rapidly decarbonising, the technological improvements in aviation – and yes they have been important – are relatively incremental and are being offset by the huge increase in demand for

flights,’ explains Lucy Budd, a professor of air transport management at De Montfort University. ‘So while individual aircraft are far more fuel-efficient than their predecessors several decades ago, there are far more of them. Aviation is still by far the most popular means of long distance international travel.’ Smoke stacks have given way to solar farms and polluting diesel trains have been usurped by sleek electric machines. But even the most modern planes still chug through tens of thousands of litres of jet fuel, just as their predecessors did.

## Worldwide aviation released 905 million tonnes of carbon dioxide into the atmosphere in 2018

#### THE SOLUTIONS

So, how to make aviation more climate-friendly? For those who absolutely need to travel far away very quickly, there has always been the potential to quickly absolve oneself from guilt: offsetting. For proponents of this system, paying a small fee to find some way to remove the equivalent carbon from the atmosphere that will be ejected by the purchase of a plane seat is an easy solution. Industry has embraced the idea, with both



airlines and various independent companies offering to take your cash and use it to cancel out your carbon footprint by planting trees, installing renewable energy, capturing methane emissions from landfills, or other similarly environmentally beneficial activities.

'My main issue with carbon offsetting is the terminology of it,' says Roger Tyers, a research fellow in environmental sociology at the University of Southampton. 'The idea that you can fly neutral – that it's a scientific, robust means of cancelling out your emissions – I think that's highly questionable.'

Tyers is keen to emphasise the positive impacts that various offsetting schemes can have, both for the environment, and economically for the people involved, especially in developing countries. And he believes the system of offsets is much more robust than ten or 15 years ago, and resistant to past incidents where money has disappeared into 'the murky world of carbon finance'. In part this is thanks to major international corporations investing in various schemes to offset their business and travel emissions, corporations that have the resources and incentives to ensure they don't have an impending PR disaster on their hands. But Tyers is still sceptical about the current system having any meaningful impact on combating climate change.

'First, we know that very few people offset their flights, you're probably looking at less than five per cent – and that's being generous,' he outlines. 'And in certain parts of the world, offsetting is completely off the map, in growth markets such as China you probably won't see offsetting at all. So if it remains voluntary then it's not going to go anywhere close to making flying sustainable under the status quo. It would need to be

something on a mandatory level, but then I would still argue that the whole concept of carbon offsetting is maybe not the path we should go down.'

Instead of dumping the problem on consumers, perhaps national legislation could be used to force the airline industry to reduce its emissions. But experts agree that there is very little appetite for this. 'Governments are nervous about being too heavy-handed with regulation to actually remove some of the very high carbon choices from people,' says Larkin. 'Also they're protecting an industry where there are lots of prospects for employment – particularly in country such as the UK where we lost a lot of our manufacturing – it's another reason why there is a reluctance to push the industry too hard.'

## The airline industry is aiming for a reduction in carbon emissions of 50 per cent by 2050

'It's a taboo area for politicians,' adds Scott Cohen, a professor of tourism and transport at the University of Surrey, 'that mobility is good, and the freedom to travel can't be constrained. And I don't think they've seen the political mandate from the people to change the situation – it would just be too dangerous for them.'

The Paris Agreement provides a globally-agreed multilateral treaty containing prospective pathways towards a more climate-friendly future. But, along with shipping, international aviation failed to make much of an imprint within this historic document. 'When

### TURBULENCE

While there has been immense focus on the impact of aviation on the climate, less discussion has considered the impact of the climate on aviation. 'Climate change is going to double or triple the amount of severe clear air turbulence in the atmosphere at aircraft cruising altitudes,' explains Paul Williams, of the University of Reading. 'That's because of the way the jet stream is responding to climate change.'

Williams expects the climate to significantly affect aviation in the future, with, for example, faster eastbound transatlantic flights and slower westbound flights as the jet stream speeds up. 'It's quite interesting that the eastbound crossing record keeps being broken,' he says, 'but that the converse is true for the westbound flights, because then the jet stream is a headwind, slowing the plane down.' Other potential impacts include difficulty with planes taking off – more of a challenge in warmer air – as well as increasingly volatile weather, lightning strikes and flooding of low-lying airports.

the Paris Agreement was being developed, there was some text to include aviation and shipping within the agreement explicitly,' explains Larkin. 'That text, in the end, was removed.'

She explains that, while there is a working assumption that domestic aviation – covering around a third of global aviation emissions – is covered by the commitments made by individual countries, that doesn't extend to the remaining two-thirds emitted by international flights. Instead, that responsibility was passed to the relevant UN agencies, the International Civil Aviation Organization (ICAO) and International

Maritime Organization (IMO). 'I think it's fair to say at the moment that the IMO has moved more decisively,' says Larkin. 'It has come out with a 50 per cent reduction target – still not enough for the Paris Agreement – while the ICAO is still running on an offset and voluntary model for now. It hasn't got anything that's sufficient to be delivering anything near what's in the Paris Agreement in my view.' Contacted directly, the ICAO shunted responsibility back to its members, responding: 'Targets agreed through ICAO represent the consensus of the 193 Member State signatories to the Chicago Convention which established us. No UN agency can tell sovereign nations what to enact in terms of targets, goals, etc. That is up to the Member States to propose, discuss and agree on.'

Since 2009, the IATA, the Air Transport Action Group (ATAG) and other actors in this industry have targeted something similar to the IMO's approach: a reduction in carbon dioxide emissions of 50 per cent by 2050, relative to 2005 levels. In order to achieve this goal, the ICAO devised CORSIA, the Carbon Offsetting and Reduction Scheme for International Aviation. Ultimately it is a mechanism that brings us back to offsetting but on a much more immense scale.

By investing in large-scale offsetting schemes, CORSIA aims to hold net carbon emissions from international civil aviation at 2020 levels, supposedly saving 2.5 billion tonnes of carbon dioxide between 2021 and 2035. Countries sign up to the scheme, the flights between signatories are monitored by airlines, and offsets are purchased to balance out any additional emissions from 2021. The practice becomes compulsory



The Airbus A380-800 is currently the world's largest passenger aircraft, flown by 15 operators globally and can take up to 868 passengers



for all countries from 2027, apart from between select developing nations and small island states, including most of Africa, South America and Central Asia. ICAO states that CORSIA 'complements the level of ambition set by the 2015 UNFCCC Paris Agreement.'

'What concerns me most about CORSIA is that passengers will assume that, because there's this scheme at a global level, it's fixed,' responds Tyers. 'That the industry has got this under control and therefore nobody needs to worry about it anymore. That kind of moral licence to carry on flying – maybe fly more – and just keep growing the industry is a big concern.'

He argues that, with a baseline that doesn't begin until 2020, that delay of mandatory involvement until 2027, and an over-reliance on offsets – not to mention China and India, the world's two most populous countries, not currently being among the signatories – the threat of national governments now feeling confident about ignoring their individual obligations to reduce aviation emissions is real and genuine.

#### TECHNOLOGICAL ANSWERS

Perhaps the dream for the industry is to follow the automotive path of moving swiftly to electric vehicles. But this is a challenge much harder to accomplish on the air than on the ground. While electric cars have kept up with their internal combustion engine-powered predecessors to the extent that many can complete hundreds of miles on a single charge, commercial aircraft have to travel thousands of miles without stopping. A battery capable of powering transcontinental flight would, with today's technology, be a hundred times heavier than its equivalent weight in jet fuel.

Nevertheless, manufacturers are investing in potential technological solutions, including market leaders Airbus and Boeing. The former has teamed up with Rolls-Royce and Siemens on the E-Fan X, a hybrid electric aircraft with a proposed launch date of 2030, while the latter is supporting start-up Zunum Aero on a similar project. The Slovenian two-seater Pipistrel Alpha Electro G2 plane is making waves as a precursor to prospective short-haul commercial flights, while the Israeli firm Eviation anticipates its nine-seater Alice electric aircraft will be ready for use by 2022.

In the UK, easyJet has talked up its partnership with Wright Electric, demonstrating an intent to have many of its most popular routes all-electric within the next ten to 20 years. While long-distance electric aviation is a distant hope, greener short-haul flight might actually be relatively more realistic in the medium-term.

But does speculation about all these 'silver bullet' technological fantasies hinder rather than help the cause? 'Technological optimism leads to inertia among policy makers,' argues Scott Cohen. 'They don't have to act now, because they buy into the idea that a technological solution is on the horizon.'

Unfortunately, such optimism clashes with the need for imminent decarbonisation in an industry that works on manufacturing timetables of a decade or more into the future. 'Say you switch to hydrogen,' suggests Cohen. 'You're not going to roll that out globally overnight. Maybe you then need 20 to 30 years until you bring everyone globally on to that kind of same

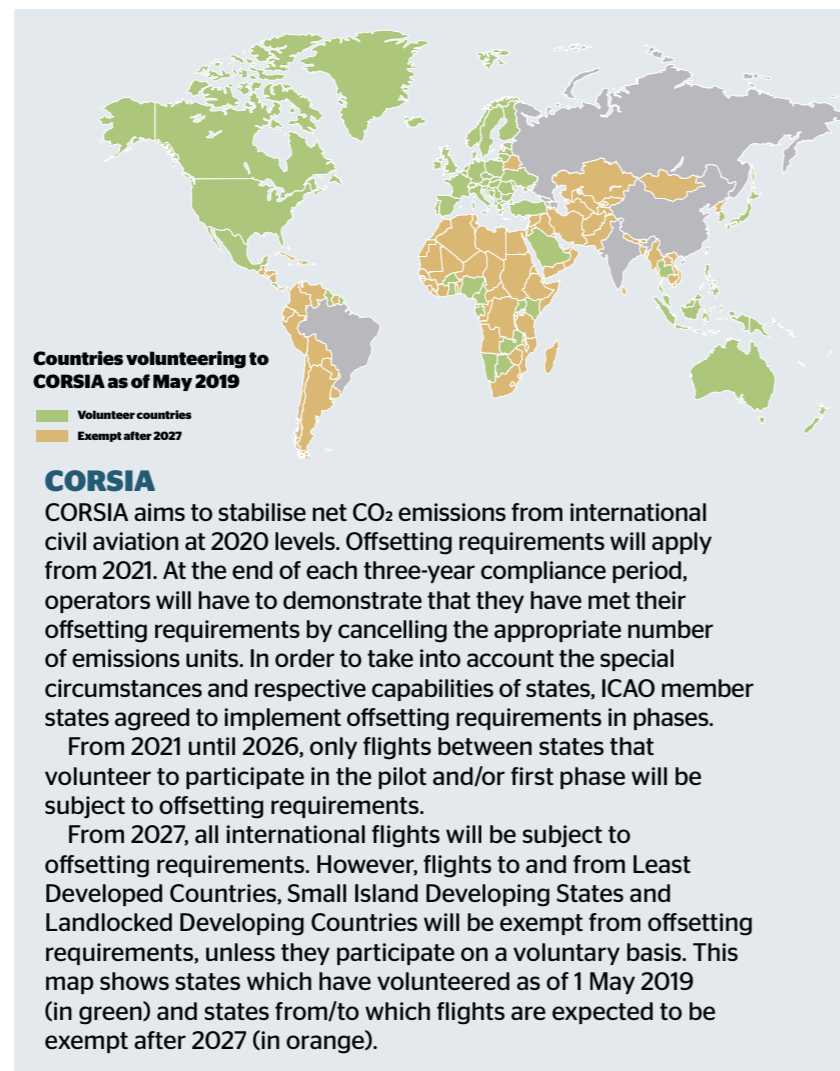
page in terms of your infrastructure. So there's a certain lock-in and path dependency that we're not going to break out of in time. By the time the fix is there, the world's on fire. Something has to be done sooner.'

Alice Larkin argues that the industry is banking too much on untested negative emissions technology – capable of pulling carbon dioxide from the atmosphere – letting it off the need to seriously cut emissions. 'We don't know that negative emission technologies are going to be operational at scale and in a time frame that is compatible with the Paris Agreement,' she says. 'Even if it turns out that all of that becomes incredibly easy, and actually we find lots of different ways of rolling out these negative emissions technologies much quicker than anticipated, it's not a very wise approach to just continue to plan for airports and aviation expansion knowing you haven't got the technology to mitigate their emissions, on the assumption that all of these other things are going to work. That's the situation we're in currently, we're making too many optimistic assumptions that aren't backed up by evidence.'

Perhaps alternative fuels, particularly biofuels, could reduce emissions without relying on the rapid deployment of untested technologies? In recent years the aviation industry has been experimenting with various sustainable aviation fuels (SAF), from recycled



The Pipistrel Alpha Electro G2 is one of several electric plane solutions currently being tested



waste to mustard seeds to alcohol. Since these fuels made their debut roughly a decade ago, they have been gradually working their way into mainstream fuel mixes, with over 180,000 flights having now been conducted using a blend of SAF. Around ten million litres of alternative SAF is now being consumed by aviation every year (this is still less than 0.01 per cent of total consumed jet fuel).

Unfortunately, such seemingly miraculous alternatives do not come without a sustainability cost of their own. 'There are several challenges with biofuels,' outlines Christopher Paling, researcher at the Centre for Aviation, Transport and the Environment at Manchester Metropolitan University. 'One is ensuring they do not compete for land with food crops which will increase the price of foods globally. Another challenge is making fuels comparable in cost to current fossil fuel-derived kerosene. This single issue of cost is restricting alternative fuels to being "demonstration" projects.'

Paling adds that the certification process required to get new biofuels to market is 'lengthy and costly'. Nevertheless, for consumers determined to vote with their wallets and fly exclusively on planes powered, in part, by SAF, there is an ICAO-supported map ([planefinder.net/custom/icao-fuel](http://planefinder.net/custom/icao-fuel)) that allows anyone to view a live feed of the handful of such planes in the sky at any one time – primarily select commercial flights departing airports either in California or Scandinavia.

#### ISSUES OF INEQUALITY

Maybe the solution is to find ways of actively reducing the number of planes in the air altogether? 'I think that it's increasingly clear that you've got to have some sort of demand reduction for aviation,' says Cohen. 'If enough people decide not to fly, you start getting a very recognisable drop in demand. The Swedish airlines

have experienced this in the past year. It's going to force politicians to rethink funding allocations.'

While Sweden's no-fly movement might yet grow to become a global phenomenon, in the absence of passengers voluntarily opting not to fly, enforcing a reduction could be a major social challenge. 'There's been some suggestion that if we implement demand management measures to make aviation more sustainable, that we could go back to a situation that was common in the 1920s and 1930s,' says Lucy Budd, 'when it was only the very richest and most politically powerful in society who could afford to fly. That invokes all sorts of challenging debates and questions about whether that's a future we want, collectively.'

Contemplating such a future raises the issue of inequality. Who spends the most time at 35,000

**'Technological optimism leads to inertia. Policy makers don't have to act now, because they buy into the idea that a technological solution is on the horizon'**

feet? 'The crazy thing about aviation is that there's an incredible skew in terms of who are the biggest offenders,' explains Cohen. 'Only two or three per cent of the global population travelled by plane in 2017. But even within that two or three per cent you have this incredible skew towards frequent flyers, in which you have a small handful of people that consume an



incredible amount of the distances flown.'

On top of those who spend an above average part of their lives collecting frequent flyer points on commercial aircraft, the growth in private jets taking to the skies on a regular basis (at least two-thirds of which are based in North America) highlights the significant role of the ultra-rich (and the tax breaks that encourage such extravagant purchases) in this problem.

While private jets require less fuel overall than a large-scale commercial aircraft, the far smaller occupancy potential means they are much less efficient per capita, making them up to ten times more carbon intensive than the equivalent commercial flight. A recent report calculated that a single private jet travelling between London and New York released the same emissions as a car driving non-stop for four and a half years. Until the one per cent begin flight shaming, the movement may be doomed to irrelevance.

#### ALTERNATIVE MODES

Maybe the pleasurable experience of travel could yet be disconnected from the relatively less pleasurable experience of sitting on a plane for hours. If, hypothetically, aviation were dismantled, what alternative forms of long distance mobility actually exist?

Perhaps the obvious answers are trains. After all, this is what the Swedes have done, boosting domestic rail travel as a record 32 million chose to shun airports in favour of old-fashioned train stations in 2018. Of course, train technology can be as varied as aircraft, and so while the average diesel locomotive might still release between a half and a third the emissions of a plane, modern high-speed trains emit only a fraction (Eurostar promotes its service as having 90 per cent less emissions than the equivalent budget flight). Given the long distances they are still capable of covering in short periods of time, rail is perhaps the obvious alternative for mobility in a climate-constrained future.

Asia paints a picture of the impact modern locomotives can have on aviation. The rapid introduction of domestic high speed rail to central and western China between 2007 and 2014 saw passenger numbers of competing aviation routes fall by seven per cent, even as passenger numbers grew by 32 per cent on routes with no rail alternative, according to a study of 642 routes by researchers at Beijing Jiaotong University and the Shaanxi Polytechnic Institute. Overall, they found that the introduction of high-speed rail to a route led to a drop in air travel of more than half over the following two years.

Han Zhiliang, president of China's Beijing Capital International Airport, has revealed that while it was once believed that rail only posed a threat to Chinese airlines on journeys of 800km or less, this has now grown to 1,000km (and is still increasing), leaving the three major national airlines – Air China, China Southern Airlines, China Eastern Airlines – re-evaluating rail as a major competitor. Nevertheless, China is still expected to be the primary driver of global aviation growth, contributing an extra one billion passengers over the next 20 years.

Across the Formosa Strait, Taiwan experienced a similar revolution when opening its high-speed rail line in 2007. The popular air route from capital Taipei

#### CONTRAILS

Climate-related charges levied against aviation don't begin and end with carbon emissions. In fact, greater than the impact of aircraft-emitted carbon dioxide (CO<sub>2</sub>) is the impact of contrails – those faint, wispy white lines that betray the presence of a jet plane far overhead. These are actually soot-filled ice clouds that block outgoing thermal radiation, leading to a warming of the atmosphere.

'Contrails are not considered in any agreement about a more climate-friendly aviation such as CORSIA,' explains Lisa Bock, a researcher at the Institute of Atmospheric Physics at DLR, the German Aerospace Center. 'One reason for that could be that the calculation of non-CO<sub>2</sub> impacts is more difficult and even more uncertain than for CO<sub>2</sub>. The impact of CO<sub>2</sub> is, for example, independent of time and location, whereas these are very important for the non-CO<sub>2</sub> impacts.' In a study with fellow DLR researcher, Ulrike Burkhardt, Bock showed that, thanks to aviation growth forecasts, the contrail effect is accelerating, estimating that the effect of contrails will be three times larger in 2050 than in 2006.

Aircraft using non-fossil fuels may mitigate the impact, with less soot being ejected and consequentially less heat-trapping ice crystals. Bock predicts that a reduction of soot particles could decrease the climate effect of contrails by about 70 per cent. 'But even if there are no soot particles in the exhaust, more ice crystals could form on aerosol particles in the atmospheric background,' she adds.



High-speed rail may be a realistic way of weaning people away from flight

HUIRICH GRANJA

in the north to Kaohsiung in the south – which once had over 100 daily flights – saw passenger numbers plummet when a 90-minute train journey became an option. A combination of cheaper tickets and less hassle saw air passenger numbers halve almost overnight, and in 2012, the last direct flight between the two cities was discontinued.

## Until the 'one per cent' begin flight shaming, the anti-fly movement may be doomed to irrelevance

Unfortunately, rail isn't always the lowest-carbon option. 'If you're already got the rail infrastructure, and you can decarbonise that through electricity, then you have options,' says Larkin. 'That's not necessarily going to be the case in some of the industrialising countries in Africa, where you might well not have the physical infrastructure. Actually building a huge rail network is also going to be carbon intensive and require a lot of steel, which also has carbon intensity.' As her research concludes, there are certainly some cases where aviation has a lower carbon penalty than constructing shiny new railways.

Of course, the internal geography of China and Europe may be well suited to rail infrastructure, but trains struggle when navigating transcontinental journeys. For anyone without access to a carbon-neutral racing yacht, oceanic crossings are considerably more of an obstacle, with only cruises, shipping vessels, and niche ethical sailing companies offering options for those willing to sacrifice large quantities of time and money to avoid flying.

#### THE PATH FORWARD

Over a century ago, when Orville and Wilbur Wright were confounding the world with their incredible flying machine, it would surely have been impossible to imagine that this technology would become so ubiquitous as to form such a substantial headache. Should aviation be grounded? The benefits created by this radical change in mobility are still worth considering. 'I think we need aviation,' argues Paul Williams. 'It's good for people to travel. It broadens peoples' minds,

it internationalises people, it brings a host of economic benefits. I wouldn't want to shut down the aviation sector. But I do want it to become a lot more sustainable.'

All the evidence gathered suggests there is no reason to believe this won't eventually be possible, that there won't be a breakthrough on some form of low- or even zero-carbon aircraft. Unfortunately, we have boxed ourselves in with an incredibly short time frame in which to develop and install the necessary technology required to continue the scale of aviation currently underway without it busting the carbon budget. In the short-term, perhaps this problem could be offset away? If not, might demand reduction need to be considered in some form until such technology is available? 'I've never been a proponent of the idea that we stop flying entirely,' says Scott Cohen, 'but there needs to be some level of moderation within it.'

Perhaps this could be achieved with national and/or international legislation, instilled with a newfound sense of urgency? Maybe the low-hanging fruit of frequent flyers and private jets should be most heavily targeted? Or does the key lie in how easily modern mobility (and the social and economic forces that shape modern lifestyles) can adapt to less carbon intensive modes of transport, such as high-speed rail?

If one of humanity's greatest achievements is to avoid becoming a relic of a bygone era, a time when humanity could take to the skies with abandon, the aviation industry may need to simultaneously make great strides with all these potential solutions to combat the harsh realities of climate change, before severe turbulence causes an emergency landing. ●