# FLYING'S GREEN FUTURE

Technological progress holds the key to reducing air transport emissions

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## TECHNOLOGICAL PROGRESS HOLDS THE KEY TO REDUCING AIR TRANSPORT EMISSIONS

### EXEC SUMMARY

The 1 billion tonnes of greenhouse gases produced every year by the air transport sector account for just 2.5% of total emissions, but they pose an outsized challenge to the goal of limiting the rise in global temperatures to 1.5˚C.

### AIR TRANSPORT AND THE CLIMATE CHANGE CHALLENGE

Aircraft emissions are notoriously difficult to abate, mostly because the renewable energy that has helped to decarbonise other industries is not a great substitute for jet fuel. At least not yet. What is more, demand for air transport is growing rapidly: from 1 billion passenger journeys in 1990, to 4.5 billion today and to 8.2 billion by 2040, according to the best available projections. Most of this new growth will be in Africa and the Asia-Pacific, where the number of journeys is expected to increase by 5% to 6% per year for the foreseeable future.

So if nothing changes, air transport could more than triple its emissions at the same time as many other sectors are racing towards zero.

So what to do?

Conversations about decarbonisation often boil down to two schools of thought: on the one hand, the idea that reducing emissions means reducing consumption; on the other, that improvements in technology will allow us to decouple consumption from environmental harm.

Air transport decarbonisation is no different. We could design our way out of trouble with more fuel-efficient propulsion, better air traffic management and battery-electric planes. Or we could cut down on flying: fewer people flying less often and less far.

The good news is that these two different pathways to lower aircraft emissions are rarely in conflict. Indeed, well-designed carbon taxes or emissions trading schemes serve both goals: they incentivise aircraft operators and manufacturers to invest in greener technologies and prompt travellers to think about alternatives to flying.

Importantly, the extent to which the sector relies on one or other of these pathways to get to net-zero depends largely on the underlying dynamics of the market, rather than any particular government policy. What matters is how sensitive passengers are to a change in ticket prices versus how easily aircraft operators can make the transition to more environmentally friendly technologies.

There is a lot of uncertainty about both of these factors, but in the last five or so years the picture has become clearer: abatement in the air transport sector in the next few decades is going to come mostly from greener aircraft, not from foregoing travel.

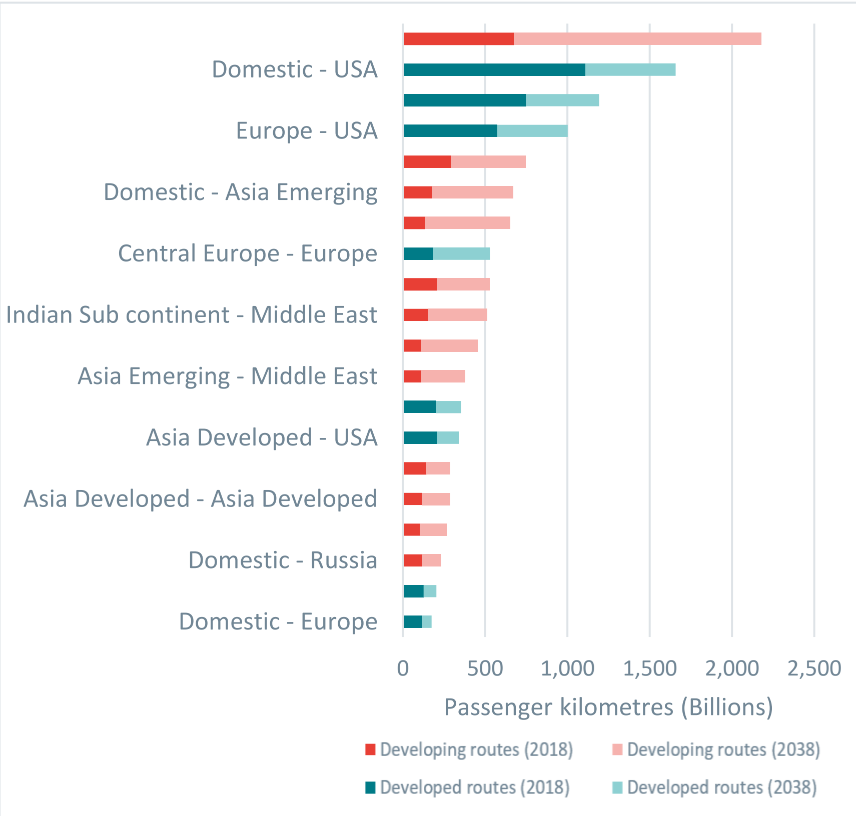
Abatement in the air transport sector in the next few decades is going to come mostly from greener aircraft and fuels, not from foregoing travel. Here's why:

## FLYING LESS

The case for flying less is straightforward. If fewer people fly, aircraft emissions will drop. But the question quickly becomes who gets to fly, and who stays on the ground?

Most of the growth in air traffic is expected to come from the developing world. Of the 7 trillion passenger kilometres per year of air travel expected to be added by 2040, 5 trillion will be to or from what are now developing regions (see the figure below). So even if rich countries were able to restrict air travel to current levels in absolute terms, total air transport demand would still more than double. Reducing overall air travel would necessarily require partially grounding the emerging middle classes in countries like Nigeria, Indonesia and Brazil — a hard sell when Europeans and Americans fly orders of magnitude more.

### FIGURE 1 PASSENGER KILOMETRES BY ROUTE, 2018 AND 2038




*Source: Airbus Global Market Forecast*
*Note: Top 20 aviation routes*

Second, short of banning air travel outright, governments would have to raise ticket prices substantially in order to discourage many people from flying. This is because most flyers are not particularly sensitive to price increases. The average price elasticity of demand for air travel is generally estimated to be 0.6, meaning that to reduce demand by 60% ticket prices would have to double (or more than double for business and long-haul travellers).

Governments can put upward pressure on ticket prices by taxing jet fuel or the carbon it emits when burned. But even if we assume that airlines could pass on all of these costs to passengers (unlikely in the short term), fuel makes up only 20% to 30% of the price of a ticket, so a tax would need to raise fuel costs to four or five times current levels to double ticket prices. This would be equivalent to a carbon tax of something like €500 to €750 per tonne of $CO_2$, much higher than even the most ambitious governments are contemplating in the near future.

Even if a tax on this scale could be agreed at the international level, rising living standards and a growing global population mean there will still be many more people flying in 2050 than there are today.

But there is another way forward.

## DECOUPLING AVIATION FROM EMISSIONS

We know that even very high carbon prices won't make much of a difference to air transport demand. But they do send a strong signal to airlines and manufacturers.

For a start. higher carbon prices can accelerate improvements in aircraft **fuel efficiency**. Since 1990, the fuel burn of the average passenger aircraft has fallen by around 0.75% a year. An Airbus A350, for example, uses about 40% less fuel per passenger kilometre than a Boeing 747. These gains have come from improvements in propulsion technology, aircraft aerodynamics and additive manufacturing techniques. And new technologies are in the works:

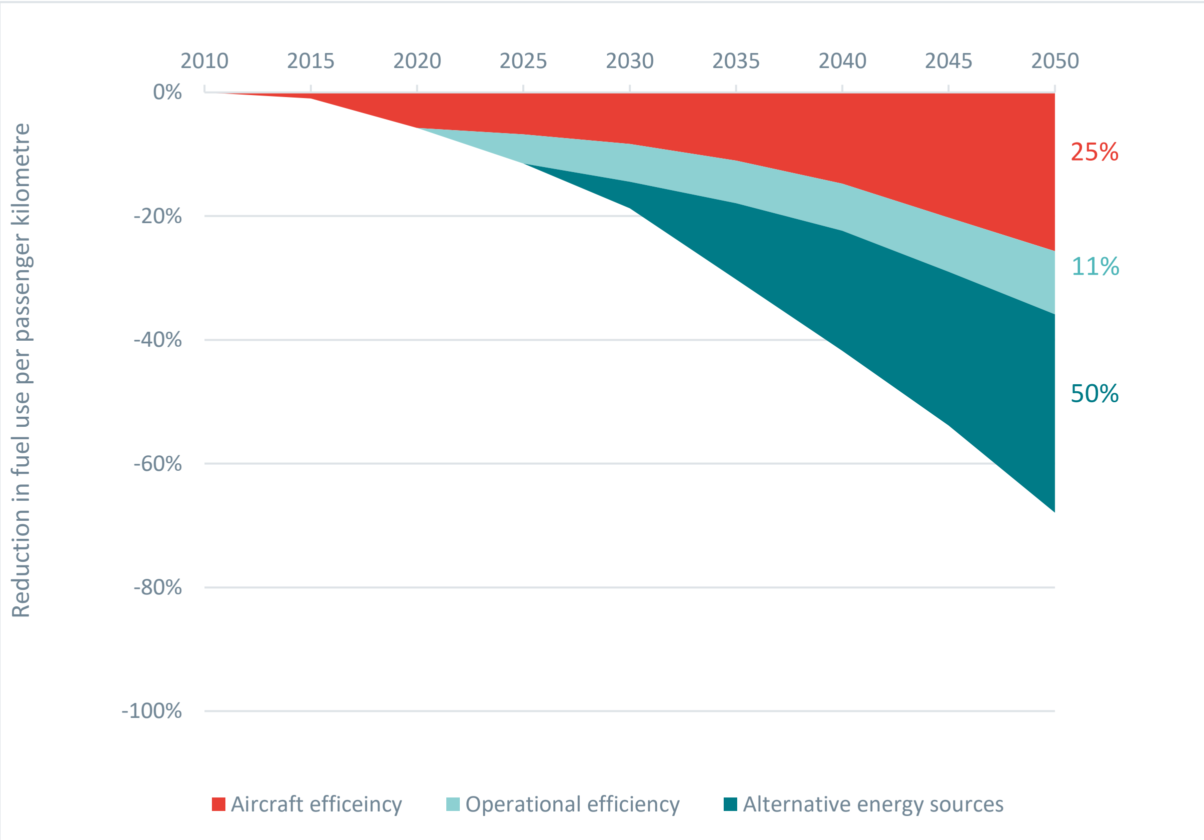
- next-generation engines with modified fan blade shapes and compressor angles, such the General Electric GE9X and the Rolls-Royce UltraFan engine, are expected to increase efficiency by 10% to 25%;
- alternative wing configurations such as Boeing's Transonic Truss-Braced Wing or Airbus's "MAVERIC" design can further reduce drag; and
- advances in additive manufacturing are helping with the design of new light-weight components.

By 2050, the International Civil Aviation Organization (ICAO) estimates that fuel efficiency can improve by as much as 25% (see the figure below).

Higher carbon prices can also spur **operational efficiencies**, such as increased aircraft load factors, more regular maintenance and improved air traffic management. For example, the Airbus *fello'fly* demonstrator involves two aircraft flying in formation to reduce drag, increasing the fuel efficiency of the following aircraft by up to 10%. Substantial emissions savings can also come through other operational innovations, such as reducing cruising altitudes to limit the warming effects of non-$CO_2$ emissions or cutting back night-time flying to limit the effects of radiative forcing. Combined, ICAO estimates that these operational changes could reduce emissions per passenger kilometre by another 11% by 2050.

Finally, higher carbon prices can incentivise switching to **renewable alternatives to fossil fuels**, such as second-generation biofuels and synthetic fuels, as well as batteries and hydrogen fuel cells on short-haul flights. Technology that has forever been "ten years away" is suddenly starting to be commercialised. The nine-seater all-electric 'Alice' aircraft with a range of 1,000 kilometres already has 150 commercial orders, and as of this year, all planes taking off from Norwegian runways must have at least some alternative fuels in their tanks. The long-term estimates here are a lot more uncertain (and much more dependent on carbon prices). But with the right price signals, the IEA's Sustainable Development Scenario suggests that alternative energy sources will power around half of all flights by the middle of the century.

## FIGURE 2 REDUCTION IN EMISSIONS PER PASSENGER KILOMETRE




*Source: Frontier analysis*

*Note: Based on the assumptions underpinning the IEA's Sustainable Development Scenario. Alternative scenarios imply slower reductions. The three decarbonisation pathways are not additive (e.g. the 50% alternative fuel reduction only applies to the residual remaining once aircraft and operational efficiency are accounted for).*

All in all, technological advances could deliver a 60% to 70% reduction in aviation emissions, independent of what happens to passenger numbers. What's more, governments would only need to agree on a relatively modest carbon price to get there, something like €125 per tonne by 2050. Indeed, long before fuel prices climb high enough to make more than a few people think twice about flying, they will have brought about a wholesale improvement in the carbon footprint of air travel.

## CONCLUSION

Good environmental policy should be technology neutral. But it should also be open minded about whether abatement comes from reduced demand or more efficient supply. While even small reductions in air transport demand will be hard to come by, innovative technologies and the increased viability of alternative fuels mean that sharp improvement in efficiency are likely by mid-century.

We know that the air transport sector is capable of mapping out a route to net-zero. The good news is that this route is likely to be compatible with a future in which everyone has access to the benefits of air travel.

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