



Factsheet

Environmental optimisation of aircraft

Overview

- The aviation industry's answer to reducing the environmental impact of aircraft is sustainable aviation fuels, or SAFs.
- SAFs generate significantly lower fossil CO₂ and non-CO₂ emissions.
- Non-CO₂ emissions do not increase and decrease in direct proportion to CO₂ emissions. A reduction in CO₂ emissions does not mean a reduction in Non-CO₂ emissions.
- The problem is that there are still too few SAFs. And they are expensive.
- Gas turbines that burn kerosene-like fuels will remain the most important form of aircraft propulsion in the coming decades.

In detail

The ideal aircraft should be resource-efficient, not have a negative impact on the climate, not affect local air quality and not generate noise. According to the FOCA, the major challenge facing aviation authorities is to select and weight environmental requirements for aircraft in such a way that the overall environmental impact is reduced without exacerbating other negative impacts or jeopardising aviation safety.

Specifically, the following conflicting factors must be weighed against each other:

- reduced fuel consumption and fewer CO₂ emissions versus higher non-CO₂ emissions such as nitrogen oxides;
- CO₂ emissions versus prevention of night-time contrails;
- CO₂ emissions versus noise;
- in the case of upgrades to existing engines, nitrogen oxide emissions versus particulate matter emissions.

Solutions do exist, however, for example, to the first of these conflicts: reducing CO₂ emissions versus reducing non-CO₂ emissions. Greater use of sustainable aviation fuels (SAFs) in future will help to alleviate this issue. SAFs generate significantly lower fossil CO₂ emissions from the aircraft. In other words, while more fuel has to be burnt in order to reduce nitrogen oxides, fossil CO₂ emissions can nonetheless be reduced by using SAFs. This situation is some way off, however, because there are still too few SAFs available, which means that stepping up SAF use to offset additional consumption will be expensive in the short to medium term.

Alternative propulsion systems

Experts around the world agree that there will be no significant alternatives in the coming decades to the current aircraft propulsion system, which is responsible for the majority of today's emissions. **Gas turbines** burning kerosene-like fuels will remain the most important form of propulsion.

Battery-powered electric aircraft will remain a niche application in the longer term, replacing flights that currently account for less than 1% of global aviation emissions. **Hydrogen-powered aircraft** (electric and using gas turbines) could replace part of the current fleet. However, it will be decades before such aircraft are operational and the infrastructure at airports is in place. Details of this assessment can be found in the [postulate report 'Carbon-neutral flying by 2050'](#).

If we take an overall view of the environmental impact, factoring in grey emissions and energy in particular, electric and hydrogen aircraft do not necessarily win out over gas-turbine, SAF-powered aircraft. A document prepared by the FOCA for the European Civil Aviation Conference (ECAC) and ICAO provides an explanation of these issues: [The big picture of emissions accounting for future aircraft propulsion systems](#).

Regulatory framework

The aviation industry needs global standards in order to function. These standards are developed in the [International Civil Aviation Organization \(ICAO\)](#), by groups of experts from ICAO's approximately 200 contracting states. The standards are implemented nationally. Environmental optimisations and measures are based on the correct determination of engine emissions – or noise emissions, in the case of noise.

One particularly thorny issue is that of **non-CO₂ emissions** and their climate impact. This is because these emissions do not increase and decrease in proportion to CO₂ emissions. It is therefore wrong to present non-CO₂ emissions as multiples of CO₂ emissions and determine measures on this basis. Regulatory frameworks and aircraft emissions statements must take this into account.

Choice of technical measures sets long-term course

Defining new technical measures requires a holistic environmental assessment. Once the course has been set in a certain direction, the consequences are long-lasting. This is because aircraft and their propulsion systems take a long time to develop – at least 10 years – and aircraft have a long service life, operating for an average of 30 years.

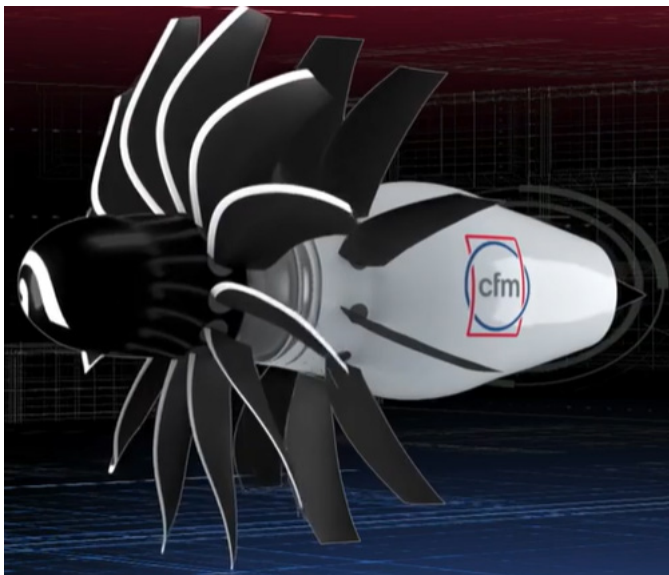
Fewer nitrogen oxides thanks to new engines

There are engines that convert fuel into thrust efficiently and so emit less climate-impacting CO₂. For physico-chemical reasons, however, this usually entails an increase in nitrogen oxide (NO_x) emissions. Nitrogen oxides are formed when the main components of air (nitrogen and oxygen) react together. This occurs at high combustion temperatures, which is precisely when fuel is burnt highly efficiently and residue-free. The FOCA advocates tightening NO_x limit values. Switzerland was a pioneer in the introduction of NO_x emission charges at airports. These charges provide extra incentive to develop complex combustion technologies that reduce NO_x. Until a few years ago, engine manufacturers managed to produce their engines with NO_x emissions well below the current, globally authoritative, ICAO limits. With current climate policies, the pressure to further reduce CO₂ has become so great that engine manufacturers have had to almost fully exhaust the current NO_x limits, this being the only way to achieve even greater CO₂ efficiency. Because market conditions have prioritised a reduction in fuel consumption, NO_x emissions have increased significantly. If this trend is to be reversed, some fuel will need to be sacrificed to NO_x reduction in future engine designs. This runs counter to further efficiency increases and CO₂ reductions. The only way to address this contradiction is by means of SAFs. Scientists cannot say for sure whether or not

present-day NO_x emissions will warm the climate in the future. The FOCA's strategy is to stipulate that NO_x emissions from new aircraft engine designs should, at the very least, not exceed those of earlier models. In recent years, it has worked within the ICAO to improve the NO_x limit values for airport-related NO_x emissions and to develop a limit for cruise NO_x emissions.

Propeller enlargement (open-fan concept)

Another attempt by the industry to cut CO₂ is the open-fan concept. Essentially, this involves massively increasing the diameter of the engine's fan blades (propellers). Large propellers are more efficient at generating thrust than smaller ones, as long as the aircraft does not need to fly too fast. The technology for this is complicated and requires a strong transmission. A 20% reduction in fuel consumption compared with today seems feasible by this means. However, large propellers perform less favourably in terms of noise. That is because they generate lower frequencies, i.e. a deeper hum, than current jet engines. It is virtually impossible to shroud the large propeller blades because of the weight and drag. Also, low frequencies are less effectively attenuated by the atmosphere and can penetrate buildings relatively easily. Even high-altitude flights could generate unacceptable noise levels. The FOCA has very stringent requirements on noise abatement. There is therefore something of a trade-off between future tightening of limit values for aircraft noise propagation and curbing fuel consumption.



CFM RISE programme. Source: safran-group.com

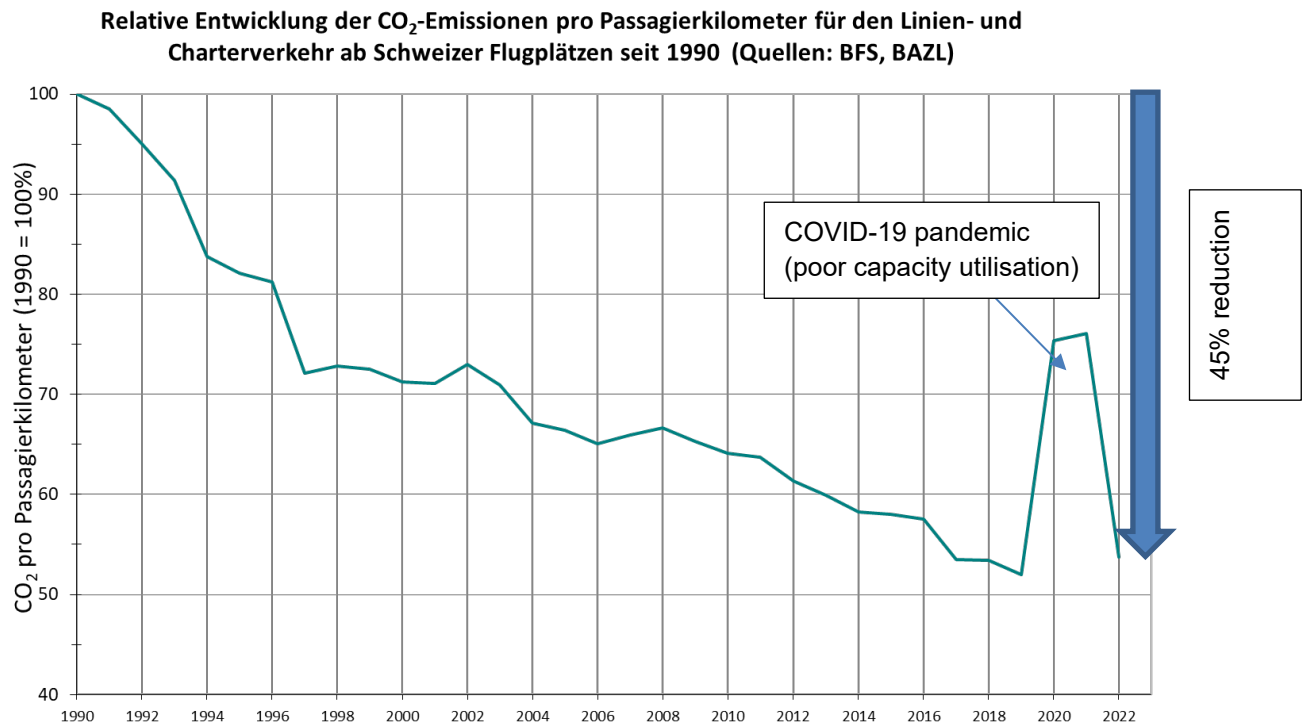
New wing means better ascent and less noise (A380)

People witnessing a take-off or landing of the Airbus A380 wide-body airliner report an astonishingly low level of noise given the aircraft's large size. This is due to the A380's innovative wing design, which allows it to climb better during take-off, thus reducing noise on the ground. Special landing gear fairings further reduce noise on landing. These measures adversely affect the aerodynamics (drag) and weight of the aircraft. According to FOCA estimates, they entail additional fuel consumption of around seven tonnes of kerosene per long-haul flight. In short, in the design of the A380, noise performance was deliberately prioritised over minimising CO₂ emissions.

Fleet renewal

Fleet renewal, whether the introduction of new aircraft or the retrofitting of existing aircraft with, for example, sharklets or winglets, can significantly affect environmental impact. Another promising option involves covering long-haul aircraft fuselage sections with a special fine-structured film that mimics shark skin.

On the graph below, the sharp drop between 2016 and 2017 can be attributed to the fleet renewal at SWISS. The new Airbus A220 short-haul airliner consumes up to 25% less fuel per flight on the same routes than its predecessor, the Avro RJ100, despite having 28% more seats. The outlier in 2020/21 was due to poor capacity utilisation during the COVID-19 pandemic. Efficiency returned to prior levels from 2022/23.



In absolute terms, the average value of CO₂ emissions per passenger-kilometre for international flights from Switzerland is currently well below 100 grams. The average consumption of all flights in 2023 for the SWISS fleet, for example, was 3.11 litres per 100 passenger-kilometres. This equates to around 80 grams of CO₂ per passenger-kilometre. Source: The FOCA verifies the consumption data based on traffic statistics and records of fuel consumption in the flight data recorders of Swiss airliners.

Further information

[The big picture of emissions accounting for future aircraft propulsion systems](#)