Energy & Environment

Zero carbon flight

How can we slash the impact of air travel on the climate while meeting future transport demand?

Our vision

At the current scale of operation and rate of growth, fossil fuel aviation is not sustainable. We need to revolutionise the way we fly. Therefore our vision for flight will be to incentivise the development of zero- or reduced-emission flight in the near term, in an aircraft that can scale up and influence the whole aviation industry by 2025.

The challenges and their context

Because aviation is almost exclusively reliant on fossil fuels, it is one of the most difficult areas to address in terms of global emission targets. A 1999 IPCC report predicted that by 2050 aviation would account for between 983 and 1,453 million tonnes of CO_2 emissions and between 5.77 and 15.84 million tonnes of NO_X emissions per year[1].

There are around 100,000 scheduled flights each day globally. A one-way flight on a Boeing 747 from London to Hong Kong illustrates the scale of aviation's impact on the climate. Total CO_2 emissions can reach up to 600 metric tons, about 1,000 kg of CO_2 per passenger. This is equivalent to almost one eighth of annual CO_2 emissions per capita in 2010 in the UK[2].

In the long-term, aviation should become a zero-emission industry. Biofuels, carbon offsetting or emission trading do not solve the problem of CO_2 accumulation in the upper atmosphere, where it can remain for decades[3]. There is also no consensus about the real effect of biofuels on carbon emissions in aviation. Zero-emission aviation would not only solve the problem of CO_2 retention, but also of NO_X emissions that enter into chemical reactions with the natural chemical composition of the atmosphere[4].

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1 Penner, J.E., Lister, D.H., Griggs, D.J., Dokken, D.J., McFarland, M., 1999. Aviation and the Global Atmosphere. IPCC, Cambridge University Press, UK. [Online] Available at: http://www.ipcc.ch/ipccreports/sres/aviation/index.php?idp=0
2 The World Bank, 2010. CO2 emissions (metric tons per capita). [Online] Available at: http://data.worldbank.org/indicator/EN.ATM.CO2E.PC
3 Sustainable Aviation, 2014. Climate Impacts of Aviation's Non-CO2 Emissions. Sustainable Aviation, May. [Online] Available at: http://www.sustainableaviation.co.uk/wp-content/uploads/SustainableAviation__nonCO2_Paper_May_2014.pdf
4 Lee, D., Fahey, D.W., Forster, P.M., Newton, P.J., Wit, R.C.N., Lim, L.L., Owen, B., Sausen, R., 2009. Aviation and global climate change in the 21st century. Atmospheric Environment, 43 (22-23):

Although zero-emission flight has already been successfully demonstrated in traditional aircraft designs (e.g. gliders, gas balloons), as well as modern ones (e.g. kytoons, solar-powered aeroplanes), work is stalling when it comes to developments that can translate into zero-emission aviation and all-purpose aviation industry in general.

Current innovation

Solar Impulse is a record-breaking solar-powered aircraft. In principle, this should be an ideal blueprint for zero-emission aircraft. However, the aircraft has to be large enough to carry enough solar cells to power the craft (72m wingspan). It has to be light so that very little energy is consumed on generating lift — it carries only its pilot and the airframe is very fragile[5]. It also has to be slow (top speed 140 km/h). Individual technologies used in Solar Impulse are promising, but the size, payload, speed and inconsistent, weather-dependent reliability present barriers for scaling it up towards practical aviation solutions.

In 2011 Slovenian light aircraft manufacturer Pipistrel won the NASA Green Flight Challenge with its Taurus G4, a fully-electric 4-seater. Airbus has already tested its E-Fan electric aeroplane with a modest 9.5 meter wingspan. A larger version of the E-Fan, as well as one with an increased range, is under development. Boeing is working on developing a hydrogen-powered Phantom Eye, with impressive endurance (4 days airborne) and wingspan (45m), however this is a pilotless vehicle.

A typical maturation path for aviation technology begins with a concept sketch or a study, which then goes through the lab and prototyping, and subsequently through testing on a demonstrator. Afterwards, demonstrated technologies progress into light aircraft in general aviation and ultimately towards large aircraft serving commercial aviation.

Existing zero-emission demonstrators have no impact on the aviation industry, because there is currently a gap in technology maturation path between the demonstrator stage and general aviation, which requires better performance, reliability, safety and cost. Although demonstrators often excel in certain performance areas, they are not made for regular, practical service. This gap between what a demonstrator can perform at a single event, and what aircraft can perform over years of service, is what we define as scalability of an aircraft.

The potential for challenge prizes

A Challenge for Flight could focus on innovators demonstrating zero- or reduced-emission flight in 2020 in an aircraft that can scale up and influence the whole aviation industry by 2025. Innovators would have to present a design study and technology maturation path(s) for a zero- or reduced-emission aircraft that could be deployed by 2025 and prove their design by building and flying a demonstrator aircraft that in 2020 will perform a zero- or reduced-emission flight with the required energy efficiency, speed, distance and payload.

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