FUTURE AGENDA
Open Foresight

THE WORLD IN 2030
Electric Aviation

Electric Aviation

As the pressure to decarbonise aviation builds, using electric planes for short and medium-haul flights gathers support. Although some technological challenges are significant, investment and regulation align to accelerate development.

Increase of aircraft fleet by 2040	**100%**
Aviation share of carbon emissions 2030	**3.5%**

A growth in the use of electric planes has the potential to significantly cut aviation emissions, reduce noise and also potentially provide cheaper travel. At a time when, globally, we are flying more, there is a tangible opportunity to accelerate new technology development to electrify aviation. While some governments and cities plan for more airports to accommodate and stimulate more flying, public pushback against higher emissions builds with little interest in temporary solutions such as more carbon offsetting. As a result, the case for truly clean aviation gains wider support and brings together deeper collaborations across research, manufacturers, airlines, cities and travellers.

The Growth in Flying

Aviation is in the midst of a significant surge. The industry directly and indirectly provides considerable economic and social impact. The sector estimates that it enables $2.7 trillion of economic benefit and 65m jobs worldwide.[1] Tourism, of which flying is a significant part, currently contributes around 10% of world GDP and accounts for a similar proportion of jobs. Demand has doubled over the past 15 years and is set to do the same again – adding another 40,000 or so aircraft in the next 20 years.[2] As a result, airlines have become more profitable in the past 5 years than they were in the preceding 40. But this is not without cost. Despite ongoing improvements in efficiency, flying will account for 3.5% of global energy related CO2 emissions by 2030, up from just over 2.5% today. There are very real concerns about the effect this will have on climate change. Indeed, according to IEA projections, it will account for around 15% of global oil demand growth by 2030.[3] So, how can the sector satisfy the appetite for travel and the demand for international trade at the same time as reducing its overall impact on the environment?

Some commitments to limit emissions growth have already been made. For instance, by 2050, the industry has agreed to reduce the level of emissions generated to half of that in 2005.[4] Several are even aiming for zero emissions by 2050 - but are relying heavily on carbon offsetting such as planting more trees as part of this.[5] Many do not consider this to be adequate. If we are to meet the goals of the Paris Agreement, some suggest that real emissions growth needs to be reversed and brought right down to zero by 2050. Over the next decade expect public and government calls for faster decarbonisation to be increasingly vocal.

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Decarbonisation of Aviation

The airline industry is seeking to improve environmental performance by introducing advances including lighter planes with better engines and enhanced fuel efficiency – but, even so, there will still be a net increase in emissions. While Boeing claims that market growth has become decoupled from emissions growth (it quotes an average 5.9% growth in air traffic over the past twenty years resulting in an annual rise of 2.4% in emissions) the sector is still increasing emissions and slowly accepting the need for faster decarbonisation.[6]

Several alternative propulsion options are being explored in research labs. However, with typical product lifespans of 20 to 30 years, a rapid changeover of the global aviation fleet to a new breakthrough design is unlikely. Instead the ambition is to accelerate the adoption of biofuels and so help to "stop emissions, not flying."[7]

The Biofuels Option

As with the car industry 30 years ago, a gradual blending of biofuels with standard fossil-fuel products is considered to be a good way to manage an environmental transition in aviation. But, although there some progress has been made, by 2018, after a decade of testing, biofuels accounted for just 0.1% of consumption and, even in the most optimistic scenarios, are only expected to 10% of the sector's fuel supply by 2030.[8] In 2020 only five airports provide regular aviation biofuel distribution (Bergen, Brisbane, Los Angeles, Oslo and Stockholm).

The problem is that biofuels are more expensive than traditional kerosene and airlines are largely unwilling to bear the cost. One option is additional passenger taxes to cover the extra expenditure which would be equivalent to around $10 for an economy transatlantic flight or $30 for London to Sydney. But in such a cost-competitive, increasingly price-transparent market, most airlines are wary of the consequences of this. As a result, although biofuels have some potential to drive down emissions, the impact of slow adoption and unambitious industry targets, suggest that they are

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Less Flying

One clear response is to fly less. Within the business world, the steady improvement and adoption in low-cost video conferencing, AR and VR technology is reducing the need for so many face-to-face meetings and team events while, with growing focus on companies' environmental and social credentials, reducing the amount of flying is fast developing as both a reputational and cost benefit.[9] It's also a healthier option. There is also a rising public movement against flying. In Sweden the concept of flight shame or 'flygskam' is causing a fall in air travel with a reported 8% drop in domestic journeys in 2018 and a 2.8% fall in international flights.

As highlighted in a Houston discussion, although there are some countries where air travel is pretty much the only international option – for example getting to and from Israel and Qatar or crossing between India and Pakistan – elsewhere there is growing support for travelling by train.

The Swedish railways experienced a doubling of demand between summer 2018 and 2019. Many now see that several other countries will follow suit: DB, the German railways operator and another beneficiary of recent demand growth, is notable in using innovative advertising to encourage more rail travel and is seen as a key player in the introduction of more European fast, direct train services.[10] With its extensive network of high-speed railways, the Chinese government is similarly keen on encouraging more people to travel by train and accelerate its target to shift towards a greener economy.

Despite this, with expanding, wealthier, increasingly urban middle-class populations the primary driver of demand, around the world there are more airports being built, more airlines being launched and more destinations becoming available. The top 20 airports globally have, for instance, added 700 additional destinations in the past decade and further development is expected as tens of major new airports are opened in the next few years. Given the growing momentum against the environment impact of today's air travel, some question the wisdom of these investments.

Electric Planes

Whatever your perspective, it is clear that the aviation sector is in need of reinvention. Long-term some are placing hope in radical new technologies such as hydrogen powered planes - but these are unlikely to have impact any time before 2050. More likely in the medium term is however the use of electric planes.

The idea of electric aviation has been in development for over a century, but industry priorities and the dominant influence of the oil sector meant that kerosene-fuel based flight received all the attention and investment. Today, as in the car industry, a number of organisations are seeing an opportunity to reassess the situation and revitalise the possibility of developing electric planes which can provide better performance than conventional designs: With an electric engine, an aircraft can, for example, maintain performance at higher altitudes where the air resistance is lower but were combustion engines operate less efficiently. The aircraft engine can therefore be less powerful but generate equivalent speed.

As we heard in a discussion in Stavanger, there are clearly technical challenges to be addressed around battery performance, fast-charging, large energy storage as well as the size of planes themselves, but the vision is that electric planes carrying up to 50 to 100 passengers could be credible for many routes within 20 years. Crucially, several regulators are in strong support. For instance, the Norwegian government has a formal target that all domestic flights will be electric by 2040 - one of the most far-reaching ambitions to date. Others, especially island communities such as the Orkneys, Hawaii and Vancouver Island are also looking to introduce small electric planes for short journeys in the next decade.

This highlights a core dilemma – whether or not the future of electric aviation is a short-haul niche market or if it could open up change at a larger scale. There are different potential uses cases for electric planes currently being debated for short, medium and long-distance routes. But, before discussing these options, clarifying the key technology challenges to be addressed is useful.

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The Battery Challenge

Although developments are required in lightweight motors, new aircraft design, more effective cooling systems and faster recharging, it the field of effective energy storage that is considered to be the primary technical focus area for many. This is all about better batteries by which we mean lighter and higher energy density. The crux of the challenge is that electricity from renewable sources is much cheaper than conventional fuel, but current battery storage options are many times heavier: Some suggest that electricity can be up to 50 times less expensive than kerosene, but jet-fuel yields about 40 times more energy than an equivalent mass of battery. This is a trade-off.

The major hurdle is ensuring the balance of how much space in an aircraft can be used for energy and how much is left for passengers and cargo. As electric planes need lots of batteries to get any useful distance, more of the aircraft weight is taken up for energy storage compared to jets, so there is less space for passengers - and thus the average cost of each flight per passenger could be higher. Moreover, traditional planes burn their fuel in flight and so gradually get up to 30% lighter during the trip – electric aircraft don't as a charged battery weighs more or less the same as an uncharged one.

New, better and lighter battery development is therefore critical, and the electric aviation industry is now making a big bet that energy storage technology will improve significantly in the future. With battery energy density currently rising by between 5 and 8 percent per year this may be possible in the long term. However, as several have calculated, for batteries to be at a point where it is economically feasible to work in small-scale aviation, they will need to achieve five times their current density - so it may take some time to achieve.[11] Yet, with NASA, Airbus and multiple leading universities all looking at potential breakthroughs such as lithium air batteries, which promise up to 1,000 times better energy per kg than today's lithium-ion designs, a growing number of researchers envisage major progress within the decade – to a point where batteries may well reach the same energy density as jet fuel. This then means that cleaner and quieter flights could become reality.

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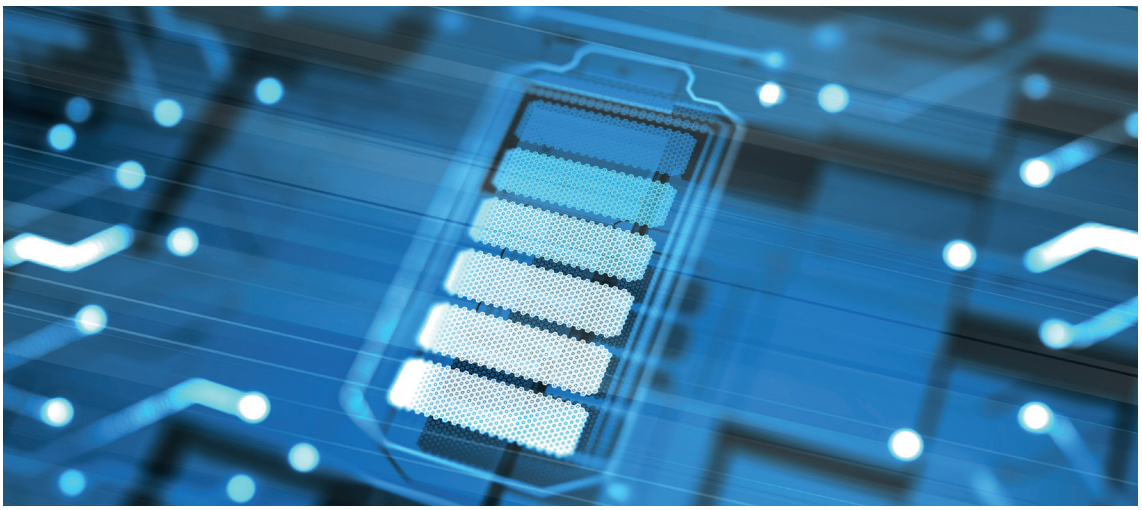

The Role of Subsidy

Potentially these electric flights could also be cheaper: policy makers have a major role to play to enable this. Subsidies are rife in aviation with many cities and government focused on driving regional economic growth using state-aid for new or extended airports and more flights. Many see that incentives need to increasingly align around cleaner flying and help bridge the transition.

The question is whether governments will aim to improve CO2 standards by just supporting carbon pricing, marginal improvements from the increased use of biofuels and wider compulsory offsetting - or if they will be bolder. Options such as higher taxes on kerosene, more stringent noise restrictions, tighter air pollution regulations and applying VAT to air travel as well as shifting the associated cost from passengers to planes are all potentially in the mix.[12] The question is which nations will lead and which will drive the scale of change that matters. As with many shifts in decarbonisation, many eyes are focused on the EU and China.

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Short Haul Flights

Of the three uses cases for electric planes, short haul flights are an early focus – from larger drones and air taxis to more substantial multi-passenger options. Electric drones for logistics applications are nearly here while passenger-carrying versions and autonomous air taxis are now in testing in Dubai, New Zealand and Australia. Commercial services are expected to launch in the next couple of years. Uber is a major investor in a design with a 100km range, but many are also looking at the Dubai Roads and Transport Authority partnership with German Company Volocopter and Air New Zealand's plans for using Google-funded, Kitty Hawk's Cora autonomous electric air taxi in the next few years. These all aim to carry up to two people and so initially will be seen as replacements for helicopters. However, there are indications that, as cargo volumes increase, drone payload capability is doubling every couple of years and so expect to see a quick transition to an associated increase in capacity over the decade.

There is also much development taking place in conventional aircraft configurations. With two billion air tickets sold each year for flights of under 800km, the business potential for small electric passenger aircraft is tangible. There is already regulatory support for this; NASA is, for example, partnering with the US FAA to come up with certification standards.[13] Globally, including air-taxi drones, there are now nearly 200 electric plane projects underway and, with many focused on this short-range market, investors can sense a major disruption on the horizon.[14]

Several concepts have already taken to the air.

- Airbus trailed its first single seat electric plane, the Vahana, in 2018 ahead of scheduled launch of a future vehicle in 2023; and
- In Vancouver in December 2019 Harbour Air undertook the world's first fully electric commercial aircraft inaugural test flight lasting 15 minutes.[15]

Others are close to first flight:

- US based Joby Aviation is perusing a multiple engine vertical take-off and landing (VTOL) design that can carry 5 people up to 240km;
- Israeli firm Eviation has developed a prototype design of plane that improves the way the propulsion system is integrated into the airframe but also has batteries accounting for 60% of the total weight. This will carry nine passengers and two crew for up to 1,000km at 3,000m at 440km/h. It is expected to enter service in 2022; and
- At a larger scale, US company Wright Electric wants to hit the sweet spot for electric travel - carrying up to 150 people about a distance of 480km in a full-sized plane – and is partnering with UK-based EasyJet that is aiming to use electric aircraft in its regular services by 2027. This is likely to be on short-haul flights, such as London to Amsterdam - Europe's second busiest route.

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Medium Range Hybrids

There is also significant development underway at the next level up – that of medium range flights of up to 1,500km. But rather than fully electric designs, the ten-year horizon is largely based on introducing hybrid planes. Here, aircraft would use a mix of conventional turbofan engines plus electric power, enabling them to cut CO2 emissions significantly by switching over to electric engines at the pivotal points in a flight - take-off and landing. Such a flexible hybrid system could be optimised to provide the high thrust required for take-off as well as the energy density needed for a long cruise.

Several demonstration projects are now nearing fruition:

- Zunum Aero, initially backed by Boeing and JetBlue, is focused on a family of hybrid 10 to 50 seat planes with a first flight planned in 2020;
- Rolls-Royce, Airbus and Siemens are working on the E-Fan X programme, which will have a two megawatt (2MW) electric motor mounted on a BAE 146 jet.[16] It is set to fly in 2021 and may carry up to 100 passengers; and
- United Technologies is working on Project 804, a hybrid electric demonstrator designed to test a 1MW motor. The firm says this design should provide fuel savings of at least 30%, should fly in 2022 and so be ready for regional airliners by the mid-2020s.

Investment bank UBS predicts the aviation sector will quickly switch to hybrid and electric aircraft for regional travel, with an eventual demand for over 500 hybrid airliners each year between 2028 and 2040.

The Long Haul Challenge

The big problem is that currently 80% of the aviation industry's emissions come from passenger flights longer than 1,500km and so rapid change will require more than just faster technology development. While short and medium range electric prototype planes are gradually gaining media attention, the prospects for electric long-haul flights are not yet so rosy.[17] Even assuming huge advances in battery technology, with batteries that are, say, 30 times more efficient and energy-dense than they are today, Airbus foresees that it would only be possible to fly an A320 airliner for a fifth of its range with just half of its payload. The larger A380, which can fly 600 passengers 15,000km in a single flight, would not reach 2,000km even if all the passengers and cargo were replaced with batteries. On present trends, addressing the long-haul challenge will take way more than the next decade, but with stronger regulatory support, greater investment, more collaboration and, perhaps most significantly, public pressure in key markets, long haul electric flight in the next fifty years need not be science fiction.

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Leading in 2030

How far we progress by 2030 is very much up in the air. Clearly with some established players' interests centre stage, not everyone wants to drive change quickly. However, with the reality of climate change increasingly apparent to the public and politicians and major shifts taking place across land transport, the pressure for meaningful change towards electric aviation will very likely build. In a sector dominated by a few global companies the arrival of a host of hungry and ambitious start-ups will certainly be challenging the status-quo.

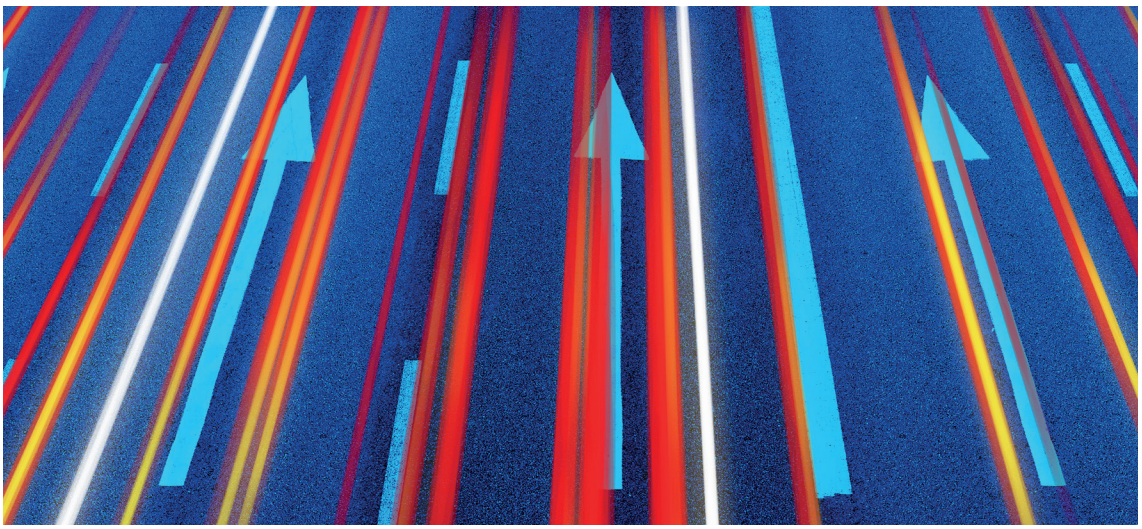
Electric planes offer a credible alternative that could radically improve performance for short haul and, as hybrids, for medium haul within the decade with multiple airlines all joining in. By 2025 we should see fully electric flying prototypes for medium range that will open our eyes for future potential. While some airlines may well continue to make slow progress with biofuels in the mix for long distance flights, many see that changing the status quo below 1500km range is a highly attractive target.

Moreover, if prices are indeed lower than conventional planes, then clean, quiet electric aviation could well open up more local routes that are currently unprofitable to operate. In doing so, in regions without good public train systems, they could offer credible zero carbon transport for many of the city-to-city trips presently done by car.

To drive progress, it is clear that multiple parties should take action:

- More governments need to join the likes of Norway in being bolder and proactive on key targets to give momentum to the ambition;
- Regulators should switch support from short-term transition subsidies around offsetting and incentivise electric planes for short and medium haul as well as driving meaningful shares of biofuels in the mix for long-haul;
- The airplane manufacturers, primarily Airbus and Boeing, should further align and collaborate more deeply with potential disrupters to the sector to accelerate technology development; and
- Perhaps most importantly, key customers – be they corporate or tourists – should become more vocal in their support for systemic change.

Everyone agrees that electric aviation can be win-win for all involved. The challenge is in building momentum.



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FUTURE AGENDA
Open Foresight

The World in 2030

This is one of 50 global foresights from Future Agenda's World in 2030 Open Foresight programme, an initiative which gains and shares views on some of the major issues facing society over the next decade. It is based on multiple expert discussions across all continents and covers a wide range of topics. We do not presume to cover every change that will take place over the next decade however we hope to have identified the key areas of significance. Each foresight provides a comprehensive 10-year view drawn from in-depth expert discussions. All foresights are on https://www.futureagenda.org/the-world-in-2030/

Previous Global Programmes

The World in 2020 was published in 2010 and based on conversations from 50 workshops with experts from 1500 organisations undertaken in 25 countries as part of the first Future Agenda Open Foresight programme. This ground-breaking project has proven to be highly accurate in anticipating future change and the results have been used by multiple companies, universities, NGOs and governments globally. Rising obesity, access not ownership, self-driving cars, drone wars, low cost solar energy, more powerful cities and growing concerns over trust were just some of the 50 foresights generated. For more details: https://www.futureagenda.org/the-world-in-2020/

Five years on, the World in 2025 programme explored 25 topics in 120 workshops hosted by 50 different organisations across 45 locations globally. Engaging the views of over 5000 informed people, the resulting foresights have again proven to be very reliable. Declining air quality, the growing impact of Africa, the changing nature of privacy, the increasing value of data and the consequence of plastics in our oceans are some of the foresights that have already grown in prominence. For more details: https://www.futureagenda.org/the-world-in-2025/

About Future Agenda

Future Agenda is an open source think tank and advisory firm. It runs the world's leading Open Foresight programme, helping organisations to identify emerging opportunities, and make more informed decisions. Future Agenda also supports leading organisations on strategy, growth and innovation.

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