AVIATION

Net zero ambitions begin to take flight

Incremental improvements to aircraft design and fuel efficiency have helped to make the aviation sector more efficient, but increasing passenger numbers mean emissions have kept climbing. Here, *Dr Cristina Garcia-Duffy* from the Aerospace Technology Institute looks at progress towards zero emissions aircraft.

We can already fly an aircraft that produces zero emissions – provided that it has been designed in an all-electric configuration with batteries. Other configurations powered by hydrogen fuel cells also have the potential to be zero (net) emissions if flight trajectories are optimised to avoid the formation of contrails. However, to build a truly zero-emission aircraft we have to consider the totality of lifecycle emissions.

Conventional aircraft produce emissions via operations on the ground and in-flight, and some of those emissions contribute the greenhouse effect that is warming our planet. Most impact on net global warming from aircraft comes from contrail cirrus, carbon dioxide (CO2) and nitrogen oxides (NOx).

But aircraft also produce emissions indirectly from the energy required for their production, in-service support (maintenance, repairs, etc), and end-of-life activities. Taking a lifecycle perspective, the total emissions for an aircraft is a combination of those produced through its production, in-service operations and end-of-life disposal.

Accelerating progress

Much of the global aerospace industry is currently focused on creating next-generation aircraft that produce zero carbon emissions while in flight. Many countries, including the UK, and individual organisations in the aviation sector, have set themselves the target of achieving net zero carbon in the next few decades. If no action is taken, air transport could be the largest contributor to total emissions by 2050. The scale of the global climate challenge and the need to respond faster will require step changes in resolve and innovation.

It is recognised that gradual technological progress will not be enough to achieve carbon neutrality. Broader solutions incorporating sustainable aviation fuels, operational and air traffic management enhancements and market-based measures, including carbon offsetting, will be required to achieve these goals and net zero carbon.

These solutions are reflected in a sustainability framework, developed by the Aerospace Technology Institute (ATI), which will guide investment through the ATI Programme into projects that address sustainability in air transport. The ATI Programme, which directs £3.9bn of joint government and industry funding into civil aerospace research, already addresses decarbonisation through 174 of its funded projects, with an estimated £780mn invested so far towards technologies that specifically address carbon reduction.

The framework will support the strategic development of a wide range of technologies and approaches to cover the spectrum of commercial aviation. The ATI has also developed environmental modelling tools and whole aircraft modelling capabilities to ensure that investment made through the programme results in sustainability benefits.

The UK Climate Assembly's recent report, *The Path to Net Zero*, argued that the public's desire to keep flying should be partially enabled by technological progress. Indeed, the incremental improvements required by society are being delivered by the ATI programme.

Large-scale engine programmes such as Rolls-Royce's UltraFan are pushing the limits of what current propulsion technologies can deliver, eking out every drop of energy efficiency. Meanwhile, projects led by SMEs, such as the ZeroAvia-led HyFlyer project, are using alternative sources of energy to take to the skies in a greener way.

Although the global focus on finding solutions to the climate challenge is approaching a new peak, the industry has been working to reduce emissions for many years. The aviation industry has consistently delivered aircraft fuel efficiency improvements of at least 1.5% per year for the past decade, in line with climate targets set by the Air Transport Action Group. In Europe, average fuel consumption per commercial flight decreased by 24% between 2005 and 2017.

In the same timeframe, the total CO2 and NOx contributions from all European flights increased by 16% and 25% respectively. The steady growth in passenger demand has outpaced the improvements from better technologies. COVID-19 excepted, this trend is likely to continue unless faster progress can be made with technology and policy measures. Between 2005 and 2017 the average noise per flight reduced by 14%. But the number of people living in close proximity to major European airports (who are therefore exposed to noise and other pollutants) increased in the same proportion.

Reductions in CO2, NOx and noise have been achieved through technological and operational improvements. Other measures, such as the EU Emissions Trading Scheme (EU ETS), and the ICAO's impending global Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA) have helped to drive progress and will continue to incentivise sustainability.

Fuels of the future

Alternative and sustainable fuels will have a major role to play in helping the UK to reach net zero carbon for the aviation sector. The CO2 roadmap developed by the Sustainable Aviation Coalition indicates that sustainable fuels could contribute significantly to the decarbonisation of the sector – if policies were changed to incentivise uptake, and the necessary infrastructure was put in place. It's important to note that current engine technology does not have to be modified in order to use drop-in lower-carbon sustainable aviation fuels: existing engines, fuel systems and refuelling facilities are compatible.

The interest in hydrogen as an

Plane insight

According to Rolls-Royce, the battery pack used in its ACCEL project is the most power-dense ever assembled for electric propulsion. When at full power during the flight-testing phase, the company says it will propel the aircraft to more than 480 km/hour setting a new world speed record for electric flight. Over 6,000 cells are packaged in the battery.

Rolls-Royce is also striving to build the aircraft in a carbon-neutral way and will use offsetting measures to compensate for hard-to-decarbonise processes. It calculated that the total carbon cost of the ACCEL initiative will be offset through rainforest preservation in Indonesia and tree planting in Scotland.

Meanwhile, in addition to its work on the HyFlyer aircraft – a Piper M-class propeller plane – ZeroAvia has developed a 'Hydrogen Airport Refuelling Ecosystem' (HARE) at Cranfield Airport. This is a micro-scale model of what the hydrogen airport ecosystem will look like in terms of green hydrogen production, storage, refuelling and fuel cell powered flight.

ZeroAvia's hydrogen-electric powertrain is designed to replace conventional piston engines and is projected to have lower operating costs than its jet-fuelled competition due to lower fuel and maintenance costs. The company plans to control hydrogen fuel production and supply for its powertrains, and other commercial customers, substantially reducing the fuel availability and pricing risks for the entire market.

Rolls-Royce is hoping to break the all-electric flight world record. *Photo: Rolls-Royce*

ZeroAvia's HyFlyer completed the world's first hydrogen fuel cell powered flight of a commercial-grade aircraft. *Photo: ZeroAvia*

alternative to kerosene is also increasing – and not only in small-scale markets. Airbus recently released its ZEROe concept aircraft – three radically different architectures, all designed for zero carbon emission flight in 2035, and all powered by hydrogen.

Alongside the Oil & Gas Technology Centre, some of the UK Catapult Centres and the Advanced Propulsion Centre, the ATI submitted a response to the All-Party Parliamentary Group on Hydrogen that highlighted the opportunities hydrogen could bring across many sectors.

Great strides are being made across many different technologies. In July 2020, the ATI launched its FlyZero project – drawing upon the collective expertise of the UK aerospace sector (and beyond) to develop a concept for a zero-carbon emission commercial aircraft for the 2030s. In parallel with this, the UK government's Jet Zero Council will investigate the possibility of developing a long-haul 'green' airliner.

In September 2020, two projects funded through the ATI Programme announced significant milestones. The Rolls-Royce ACCEL (Accelerating the Electrification of Flight) project completed ground testing of the pioneering technology that will power the world's fastest all-electric plane.

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The technology has been tested on a full-scale replica of the plane's core, including a 500 hp electric powertrain powerful enough to set world speed records, as well as a battery with enough energy to supply 250 homes. The first flight is planned for later this year and Rolls-Royce is aiming to beat the current all-electric flight world record early next year.

In the same week, ZeroAvia announced that its HyFlyer project had completed the world's first hydrogen fuel cell powered flight of a commercial-grade aircraft. ZeroAvia will now turn its attention to the next and final stage of its six-seat development programme – a 400-km zero carbon emission flight out of an airfield in Orkney before the end of the year. The demonstration of this range is roughly equivalent to busy major routes such as Los Angeles to San Francisco or London to Edinburgh.

But many tasks lie ahead. Not least is scaling up these solutions to cater for the huge demand in air travel, which has outstripped the pace of technological development. To build a truly zero emissions aircraft, a whole aircraft lifecycle approach is required, encompassing development, manufacturing and assembly, decades of use and end-of-life disposal. Similarly, a well-to-wake approach to fuels is needed to minimise the impact of production, distribution and end use of hydrocarbon-based aviation fuels (whether these are fossil fuel kerosene or more sustainable alternatives).

The same kind of scrutiny must also be applied to alternative energy sources used for aircraft, such as batteries or hydrogen. A technology that produces zero in-flight emissions is not necessarily zero emissions over the course of its lifetime. In the face of technological and environmental challenges, the case for continued investment from government and industry into these important research programmes has never been stronger. ●

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