UK Research and Innovation

UK Civil Aviation Authority

Innovation Hub

Towards Net Zero Aviation

UK Legislative Framework

Introduction

Net Zero technologies have become a core trend in aerospace and aviation, underpinned by ambitious Government targets and growing industry investment. Legislation and regulatory decision making plays a key role in enabling these.

This publication provides an overview of the current aviation legislative frameworks and associated regulation, against the context of emerging net zero propulsion technologies.

It demonstrates that many of the current frameworks in the UK can - and will - accommodate the continued development of industry-led solutions to create a greener and cleaner aviation sector for the future.

However, this publication also recognises that new technologies need to be reviewed against current regulatory processes. It starts to identify the much-needed work to ensure that the legislative framework is underpinned by new or modified policies and guidance that reflect the novel aspects of net zero technologies. This is particularly key as the technologies continue to evolve, with the aim of becoming safely integrated into the future aviation sector.

The CAA has a strong role to play in this process as the UK's safety regulator for aviation. However, Government and industry are equally important for enabling innovations to flourish safely over the next two decades and beyond.

What is Net Zero Aviation?

The Government intends to develop UK capabilities for net zero aviation, as part of its broader decarbonisation agenda for the UK and to reduce UK emissions in line with the Paris Climate Agreement.

To set the UK on its path towards net zero aviation, the Government has proposed a multi-track approach; looking to achieve the significant changes needed through multiple approaches, especially in terms of investing and supporting the development of a range of technologies in the aviation sector.

Taking an aircraft technologies focus, this means considering a range of changes to current aircraft propulsion technologies and fuels including: Sustainable Aviation Fuel (SAF); Lithium chemistry batteries; and Hydrogen.

These areas form the basis upon which this report has been created, and the case studies against which the current aviation legislative frameworks have been reviewed.

The 2015 Paris Agreement is an international commitment to limit global warming to below 2 degrees Celsius, preferably to 1.5, compared to pre-industrial levels. Achieving this will require countries to limit carbon emissions and reduce it to net-neutral by 2050.

This report is the first publication associated with the CAA Net Zero Propulsion Programme: established within the CAA Innovation Hub to coordinate and help develop work in this area. This research work was funded and supported through the Future Flight Challenge, and in association with the Jet Zero Council.

UK Legislative Landscape

What does the legislation mean for Net Zero aims?

Compared to many other sectors in the UK, the legislative structure for aviation regulation is set at a high level; to enable a relatively large degree of flexibility in how it is applied. As a result, the legislative frameworks that exist are largely non-specific when it comes to individual technologies. They establish straightforward - but vital - principles to encourage improvement and development of new alternatives.

On this basis, concomitant with the right legislative structure, is the need for the right rules and regulation to sit underneath it. How regulatory requirements are imposed is a policy decision: made usually by the Government or in some cases (delegated to) the regulator.

Regulations may specify how a piece of technology is to be used or how a process is to be conducted, in order to ensure that the technology is used safely and appropriately. For aviation regulation in the UK, it can be affected by simple changes to legislation, the inclusion of special terms into licences, or by declaring certain standard licence conditions to be met.

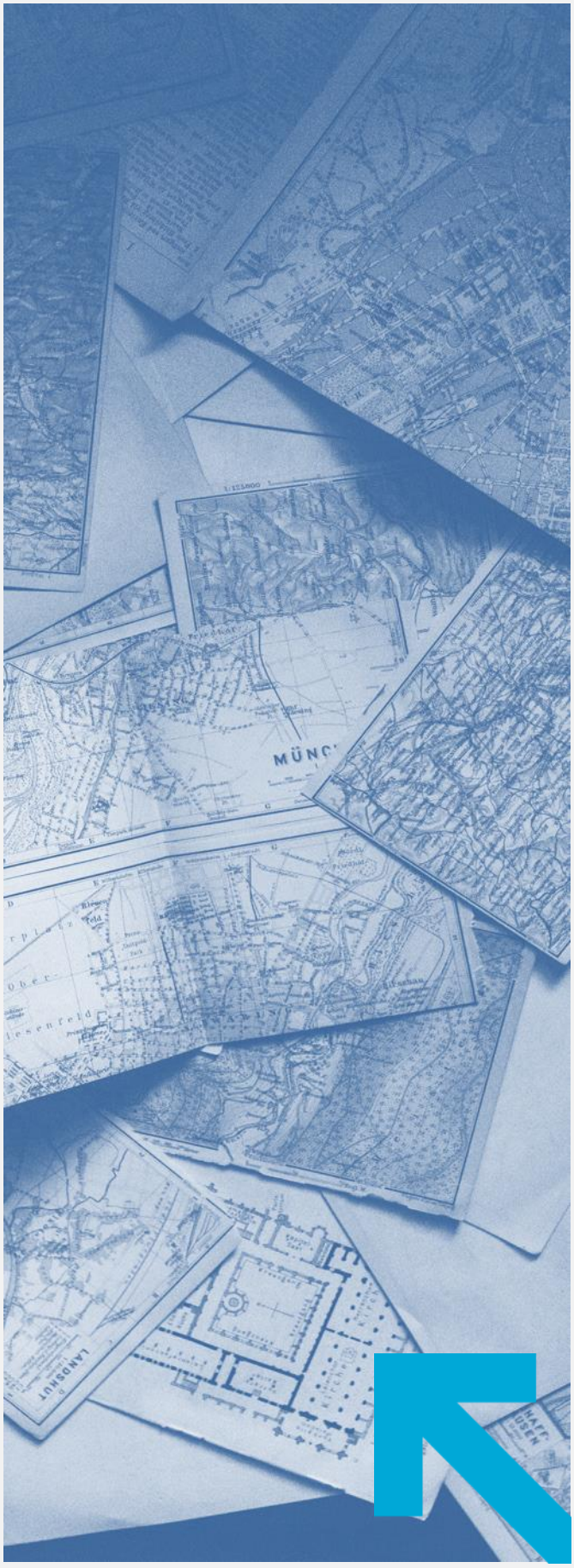
Licences in aviation cover a wide range of operators and other stakeholders. We will touch on some of the regulation relating to this in this report (as well as focussing on the overall legislative structure).

Net zero aviation relates to a number of different areas under aviation regulation. For this report these principally fall into one of the following novel areas:

- SAF – production and use as an alternative fuel source in aviation;
- Design (or Certification) of engines and aircraft - creating a system or systems for a different power source, including hydrogen and electric propulsion;
- Aerodromes and ground infrastructure - to enable the above novel operations in a safe and integrated way, including safe storage and treatment of fuels.

We cover some of the key current questions but are not able to capture them all at this stage and we recognise the evolving nature of these topics means new questions should be expected to emerge as developments continue to evolve and change.

In focusing on the above three areas where significant discussion and industry-led development has already taken place, we aim to identify in this report questions for legislators and regulators to work on collaboratively with the private sector.



Sustainable Aviation Fuel

SAF Production

Sustainable Aviation Fuel (SAF) is fuel derived from non-petroleum based renewable sources that is capable of being used as a replacement for, or blended with, kerosene. It can be used in current jet engines with no modification required to the engine itself. There are a number of processes to produce SAF, such as using biomass crops, algae, waste cooking oils, or synthesised fuels from hydrogen waste or direct capture carbon dioxide.

Over 180,000 flights have already taken place using a blend of SAF with a number of airports worldwide regularly distributing SAF. What is new however is the potential for SAF to replace traditional aviation fuel in future (i.e. the scale of its use), as well as the potential for pure SAF to be developed.

Considering the current sector, 'aviation fuel' is referred to in a number of different regulatory and legislative contexts. Existing laws do not specify a mandatory composition for aviation fuel but there are existing industry-developed standards -recognised internationally - providing guidance and requirements for those who choose to sign up to them. The principle ones are considered below.

The standard for certifying jet fuel against a voluntary consensus for ATSM standard D1655 (Standard Specification for Aviation Turbine Fuels). To meet this standard, SAF must be blended with no less than 50% conventional jet fuel to meet the requirements of the standards.

Applicable also to some SAF cases– and other aviation fuels not derived from petroleum crude oil - there is also the recognised standard from ATSM D7566 (Standard Specification for Aviation Turbine Fuel Containing Synthesised Hydrocarbons).

There is no similar standard yet developed for sustainable leaded aviation gasoline (AvGas). However this does not prevent gasoline of this kind from being commonly used in piston engine general aviation aircraft. (This usage is covered under standards for petroleum-based AvGas).

In practice these standards come under focus during the certification of the products' (engine and aircraft) development stage. Under this, documentation is required that sets out fuel usage and fuel types approved for use. The operator must use fuel of a type which conforms to the composition approved under the type-certificate process (covered under the design and certification section of this report).

In legal terms, rules for the use of fuels can also be found under taxation related Government mandated schemes. This is wholly outside of the CAA's remit but may need to be considered by policymakers. For SAF, the Renewable Transport Fuel Obligations ("RTFO") scheme currently applies. This scheme imposes obligations on fuel suppliers to supply a certain quantity of renewable transport fuels.

What does the current legislative framework tell us about the future of Sustainable Aviation Fuel?

Our review does not find any legislative blockers to the further development of SAF in the UK. In fact, existing Government mechanisms for bringing in policy changes that could result in further development and use of SAF for aviation have already been identified. For example, the Government through its consultation "Sustainable aviation fuels mandate: A consultation on reducing the greenhouse gas emissions of aviation fuels in the UK" is already considering plans to bring in a SAF blending mandate.

Also in relation to production, through non-legislative change the Government has signalled its support for SAF production to increase in the UK. Under its 2021 Jet Zero Consultation and Decarbonising Transport plan, it announced industry funding for "the development of first-of-a-kind production plants turning waste into sustainable aviation fuel."

Irrespective of the outcome of the SAF mandate decision, development of the production and use of SAFs may bring changes to current standards. This is likely to include industry-led discussion in collaboration with regulators and policymakers to make full use of opportunities to contribute towards net zero efficiencies. *In the following section we recognise the link between SAF and aircraft engine certification.*

Design and Certification

As well as considering sustainable fuels, a number of organisations have declared that they are working on powertrain, or engine technologies to create propulsion systems using electric, electric-hybrid or other means to develop future net zero aircraft

Other organisations are creating such propulsion systems as integrated parts and core design features of wholly new aircraft, such as electric Vertical Take-off and Landing (eVTOL) aircraft for Advanced Air Mobility.

The certification of aircraft and related products is governed by Part 21 of UK Regulation (EU) 748/2012. Article 2(1) states that products – defined as propellers, engines and aircraft -, parts and appliances shall be issued certificates as specified in Annex I of Part 21 for aircraft registered in the UK.

Part 21 provides for a suite of certificates for which various actors in the aircraft design, manufacturing and operations sectors might apply, as well as the rights and obligations of the applicants for and holders of those certificates.

Whilst each applicant's individual journey is different, the process is the same under the regulation for traditional and novel propulsion technologies e.g. electric propulsion aircraft or hydrogen fuel cell propulsion system engine, within a retrofitted certified airframe. This is underpinned by the statement that "to commence the process an applicant for a Type certificate must make their application "in a form and manner established by the CAA", providing certain basic information."

A set of standards and performance classes for aircraft are also prescribed by UK Regulation (EU) 965/2012. These performance standards will be particularly important for aircraft which fly for the purpose of public transport, as required by ANO Article 127.

More information on engine and aircraft design can be found on the CAA website.

What does the current legislative framework tell us about the future of Sustainable Aviation Fuel?

The legislative framework as it stands does not prevent net zero propulsion technologies in the form of engines or aircraft from becoming certified. Indeed, you can see public statements from some frontrunners in the UK confirming their regulatory journeys are already underway.

The CAA plays a key role in the certification process and the setting of minimum requirements and standards for certification for the UK, against the broader aviation standards set by ICAO. The CAA together with designers and manufacturers will develop detailed certification specifications to assess new technologies and new aviation use cases to satisfy themselves of the safety of new types of aircraft and propulsion technologies.

Whilst there are no legislative blockers to the certification of new propulsion systems powered by SAF, electric or hydrogen, the development of appropriate standards and special conditions for these systems – and the requisite aircraft – are likely to be needed. This will be a considerable undertaking for all parties. Similar processes and requirements will also apply to the development of maintenance processes, practices and training: specific to each new technology and operation. The CAA and industry will need to continue to work together to create appropriate standards and processes for the new technologies as they develop, absent a more fundamental change in approach. As both parties will be learning iteratively, tests and demonstrators of these new technologies may play a significant part in the end development of standards and processes too.

Aerodromes

We have considered novel changes to aircraft based around net zero technologies. We must also consider these against the whole aviation ecosystem.

To do this we looked at the current legislative framework against the implementation of net zero technologies and how these technologies will interact with broader aspects of the system. Namely, the new technologies in the context of aerodromes and ground operations.

The current legislative framework details how aerodromes - covering small private airfields or single use heliports, to the UK's international hub airports - operate.

Unlike some other sectors, aviation has a well-established performance-based oversight approach focused squarely on safety performance and risk. This means that there are often different rules and levels of requirements depending on these factors.

The level of complexity of an aerodrome's operations dictates many of the rules and accountabilities they will be required to meet. When it comes to introducing net zero technology-based operations therefore, there will not be a one-size-fits-all regulatory approach. The rules developed will take into consideration specific safety performance of those technologies in the same way as they would for conventional technologies.

Under the current framework, there are some consistent legal points we can draw from to consider aerodromes as a whole.

Definitions under current legislation define an aerodrome in broad terms. Under one core set of provisions for example, UK Regulation (EU) 2018/1139 defines an aerodrome as:

> "a defined area, on land or on water, on a fixed, fixed offshore or floating structure, including any buildings, installations and equipment thereon, intended to be used either wholly or in part for the arrival, departure and surface movement of aircraft."

On this basis, there are not legal impediments to the types of modified or novel operations (or technologies) that can be found at an aerodrome.

Current regulatory frameworks also enable modifications and new technologies or operations to be put in place under the authority of the aerodrome.

In practice, this means ensuring new or modified operations – of any kind – are properly managed under the aerodrome's Safety Management System (SMS).

The SMS is assured through the CAA's approval and continued oversight. To be effective, the SMS needs the right policies, processes and procedures in place, in addition to the safety leadership to enable it to perform.

The legislative framework does set out specific requirements pertaining to the role of ATM, specific safety equipment, etc. However, the basis for this is to ensure the requisite aerodrome authorities meet safety standards. In this way, the regulation imposes no specific requirements on aerodromes that would prohibit (safe) novel or changed technologies or operations.

Another common aspect to consider, is that aircraft are required to refuel or recharge at an aerodrome. Whilst there will be a number of technical and practical considerations in introducing net zero propulsion aircraft to airfields and airports, the legislation pertaining to the supply of fuel to aerodromes, is again flexible in enabling new or alternative solutions to be introduced.

For example, the definition of "aviation fuel" in Article 220 Air Navigation Order 2016 ("ANO") captures an array of potential novel fuels including gaseous and liquid hydrogen, ammonia and liquid organic hydrogen carriers. Therefore aerodromes are not legally prevented from supplying these types of propulsion. Similarly, when it comes to legislation providing obligations for the safe storage of aviation fuels at aerodrome, the above novel types of fuel would apply. However, under both of these provisions, it is unlikely electricity or electrically stored energy in batteries (for propulsion) is could be taken to apply for "aviation fuel".

Returning to the topic of storage and treatment of fuels, UK Regulation (EU) 2018/1139 sets out certain minimum requirements for certified aerodromes in Section IV, with Article 33 providing that aerodromes, their equipment and operations must comply with the essential requirements in Annex VII and Annex VIII.

Aerodromes Cont.d

These minimum requirements were set without net zero propulsion in mind and whilst there appear to be no legislative blocks under these stated sections, it may be an area for further consideration to make sure policy decisions as well as guidance is consistent and clear when it comes to novel technologies and how fuels should be safely stored for use. For example, whilst SAF may require little modification to existing storage infrastructure, the storage and distribution of liquid or gaseous hydrogen is recognised by scientists across all sectors as highly complex. From an aerospace engineer's perspective it is generally agreed that hydrogen has not yet been fully demonstrated as being in a state of technological readiness for widescale deployment in the commercial aviation sector. Further exploration of what this use means for storage and distribution/ refuelling is needed.

Similarly, batteries differ again from conventional re-fuelling practices and it is likely aerodromes will require facilities for charging for these aircraft - either to recharge the batteries separately or within the aircraft. Requirements could include AC and DC charging points, and storage facilities for replacements, safety pre-checks and maintenance.

Under current rules for certified aerodromes, a further obligation is placed on the aerodrome operator to verify that organisations involved in storing and dispensing of fuel/energy for propulsion to aircraft have procedures to ensure that aircraft are provided with fuel/energy for propulsion, which is uncontaminated and of the correct specification. This regulation does not regulate the content or provenance of aviation fuel and it would not prevent the use of sustainable fuels, provided it is fit for use in the aircraft. However, due to the comparative complexity and extreme novelty of hydrogen, we may question this or at least consider other technical and economic challenges for the supply of hydrogen to aircraft at aerodromes.

Under these challenges, there are also non-aviation specific regulations that may impact upon the use of hydrogen at aerodromes. For example, hydrogen is classified as an explosive industrial gas and subject to such regulation as The Control of Major Accident Hazards Regulations 2015.

There are presently no UK legal requirements or standards as to the quality or purity levels required for aviation hydrogen, but a number of international standards exist for the use of hydrogen in road vehicles, e.g. 'ISO 14687:2019 Hydrogen fuel quality' and 'SAE J2719_202003 Hydrogen Fuel Quality for Fuel Cell Vehicles'. SAE is currently preparing a standard, 'Liquid Hydrogen Storage For Aviation AS6679'. This defines the technical guidelines for the safe integration, operation, maintenance, and certification of Liquid Hydrogen Storage Systems (LHSS) in aircraft and defines guidelines for safe refuelling of these aircraft.

As the technology matures, the UK will be required to adopt standards and guidance for the purpose of meeting the above regulatory requirements, in particular how aerodromes will meet sampling and grading requirements to ensure the fuel is fit for use in aircraft.

what does the current legislative framework tell us about the future of net propulsion technologies under aerodrome operations?

Much of the current regulatory frameworks for aerodromes demonstrates the aviation sector's established flexible regulatory approach, which leaves much to the individual decision-making of CAA experts in coordination with the accountable industry representatives. The frameworks can be applied to novel technologies in an appropriate and proportionate manner without further legislative change. However, in order to inform CAA oversight and safe integration of these novel technologies a great deal of skills and knowledge will be required. Only in working collaboratively with industry and supported by other stakeholders such as policy makers can these be obtained for new technologies. It is also a necessarily iterative process, for both the private and public sectors as they continue to learn about evolving net zero possibilities for aviation.

There are specific areas under the current regulation, that need to be explored further to ensure it does not unconsciously create a gap in the net zero regulatory pathway or that rules applied today to the storage of aviation fuels work and provide the same level of safety for newer ones. The definition of "aviation fuel" in Article 220 Air Navigation Order 2016 ("ANO") has been highlighted as needing further clarification. Particularly, in relation to integration at aerodromes to bring in net zero technologies for battery and hydrogen propulsion for the first time, modifications will be required or at least fully considered.

Whilst some of the solutions will need to be led by industry, it will be important for the Government and the CAA to continue to work with international partners to enable unified solutions to secure the availability of new propulsion technologies, including for technologies that are developed in one country to be validated for use in another.

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