Flying start

Establishing the UK as a leader in zero emission aviation

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establishing the UK as a leader in zero emission aviation

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Summary

> **Zero emission flight is a significant economic opportunity.”**

The UK has a thriving aerospace sector which helps to drive regional economic growth.

Its expertise in engines, wings and fuel tanks, and advanced manufacturing could, however, become obsolete over the coming decades as the industry looks to end its use of polluting fossil fuels to power planes. Aviation is a major contributor to climate change and, as other sectors decarbonise, its contribution is set to grow to 59 per cent of total UK greenhouse gas emissions in 2050.

Fortunately, the UK's existing expertise mean it is perfectly positioned to take a lead in developing the technologies for zero emission flight (ZEF). This is a significant economic opportunity and will help the aviation sector play its part in the country's efforts to combat climate change.

The prize for the UK is huge if it can pioneer hydrogen powered flight specifically, with a potential increase in the economic contribution of the sector to £37 billion gross value added by 2050, up from £11 billion in 2023.[1,2] But other countries also have their eyes on this prize.

For the UK to secure the benefits and drive aviation's decarbonisation, the government needs to create the right framework to align the development and commercialisation of ZEF technologies, the building of airport infrastructure needed and the availability of ZEF aircraft for operators to buy or lease.

To signal intent to make the UK a world leader in developing and commercialising ZEF, the government should:

1. Set a target for 50 per cent of domestic flights to be zero emission by 2040.

2. Establish a zero emission flight route between Bristol, Glasgow and Belfast by 2030.

3. Provide a well co-ordinated funding and innovation environment.

4. Require airports to update their five year master plans to incorporate hydrogen infrastructure.

5. Introduce a kerosene tax on domestic flights.

A major industrial opportunity

> **“The future of aviation will be focused on ending the use of polluting fossil fuels to tackle climate change.”**

The UK has one of the world’s largest aerospace industries, anchored to world leading research and development hubs. The industry employs a highly skilled workforce of more than 100,000 people, focused on advanced manufacturing, and contributed £11 billion gross value added to the UK economy in 2023.[3,4] The UK aerospace sector is export driven, totalling £20 billion in 2023, with aircraft and their associated parts accounting for a larger than average share of exports compared to other countries.[5,6]

The sector is dispersed, with regional clusters in the South West, East Midlands and North West, providing a point of growth for regional economies.[7] It is a thriving and dynamic industry, 96 per cent of which is small and medium sized enterprises.[8]

However, the future of aviation will be focused on ending the use of polluting fossil fuels to tackle climate change.

Prime Minister Keir Starmer has acknowledged that “there is a global race on for the jobs of the future in relation to net zero”.[9] For the UK aerospace industry to maintain its status and grow, it needs to be at the vanguard of ZEF. No country has yet taken a march in this race, so the UK, with its expertise in engines, wings and fuel tanks, is primed to lead the way.

In this report we explore the climate impact of aviation, what ZEF is and the three areas of action needed to make it a reality in the UK.

Aviation is off course to decarbonise by 2050

“Aviation’s proportion of emissions will increase dramatically as other industries decarbonise.”

Flying accounted for eight per cent of UK carbon dioxide (CO_2) emissions in 2023.[10] Of that, 93 per cent was from international aviation.[11] Aviation’s proportion of emissions will increase dramatically as other industries decarbonise, growing to 16 per cent of total UK greenhouse emissions in 2035 and 59 per cent in 2050.[12] Its climate impact also includes other effects unrelated to CO_2, such as water vapour and the long contrails that trap thermal radiation and warm the planet, which may have similar or greater warming effects than CO_2.[13,14] Aircraft also produce particulate matter, worsening air quality and causing health problems.

The government has a Jet Zero Strategy to reach net zero emissions by 2050. This includes the ambition for all domestic flights to be net zero by 2040. Though this could be done through offsetting fossil fuels and the development of sustainable aviation fuel (SAF), which is the government’s current focus, there are issues with both.

> Tackling aviation emissions effectively requires new zero emission energy sources and aircraft.”

The strategy envisages an increase in passenger numbers of 52 per cent by 2050, but analysis shows that increasing fuel demand, driven by airport expansion, would undo any projected carbon emissions reductions from using SAF.[15,16] Offsetting has limitations, particularly around availability, cost and the impermanence of some solutions.[17]

Potential development and deployment of ZEF in the coming decades should be part of the plan to cut aviation's CO_2 emissions and its non-CO_2 effects. But its deployment should not be used as a justification for increasing airport capacity, given it would take many years to replace the existing fossil fuel powered airplane fleet with zero emission planes.

Tackling aviation emissions effectively requires new zero emission energy sources and aircraft. Developing and commercialising these technologies in the UK could propel the industry towards meeting its share of the UK's climate goals, as well as futureproof this thriving sector by creating a market for the emerging technologies.

What is zero emission flight?

> **Multiple zero emission flight technologies are in development.”**

Zero emission flight (ZEF) is defined as flight in an aircraft that produces no carbon-based emissions from its exhaust.[18] Depending on the fuel, there may still be emissions that cause global warming, such as water vapour. The term ZEF is used in this report to be consistent with the terminology used by the government.

Multiple ZEF technologies are in development and it is unlikely that one single technology will dominate the market. Different technologies will serve different purposes. Battery electric and hydrogen fuel cell technologies, for instance, are likely to service shorter routes with smaller planes, while hydrogen combustion will be more suitable for longer routes and larger planes.

Sustainable aviation fuel is not zero emission

Sustainable aviation fuel (SAF) is an alternative fuel made from non-petroleum feedstock that only reduces the lifecycle emissions associated with producing jet fuel, not the CO_2 and non-CO_2 emissions caused by burning it.[19] It will play a role in decarbonising the sector, especially power-to-liquid (PtL) SAF which offers a 100 per cent reduction in carbon emissions, compared to fossil fuel kerosene, when the CO_2 used to make it is captured via direct air capture (DAC).[20] But PtL SAF, at the level available, cannot provide significant emissions cuts overall, especially with the predicted growth in passenger numbers. PtL is also likely to have a higher price than hydrogen as a direct fuel.[21]

Despite its name, not all SAF is sustainable. When made from biofuels, such as used cooking and other waste oils, known as HEFA (hydrogen esters and fatty acids), it may indirectly contribute to deforestation and displace food production. HEFA is predicted to form the majority of SAF production up to 2030, before the government's SAF mandate requires the higher use of PtL from 2028.[22]

Battery electric

Battery electric planes use a dense, high powered battery system to propel an electric motor, typically in smaller and lighter aircraft. These have no in-flight emissions. This technology is in development but is not expected to be capable of powering medium or long haul flight and will only start to be commercially available for short haul for aircraft with up to 100 seats by 2040 at the earliest.[23]

> **"Hydrogen fuel cells and combustion are the technologies most likely to decarbonise medium and long haul aviation."**

Hydrogen fuel cells and combustion

In this report, we focus on hydrogen power, as current projections suggest hydrogen fuel cells and combustion are the technologies most likely to decarbonise medium and long haul aviation. Medium and long haul flying accounts for most of the UK aviation's emissions.[24]

Stimulating the uptake of hydrogen through an initial focus on short haul aviation will help to develop the technologies required for longer routes. While different hydrogen technologies serve different niches in the sector, there is overlap between them in components, standards and practices, the development of which will benefit all types of the technology. Hydrogen is an indirect greenhouse gas so ensuring low leakage rates during transportation and storage is crucial for delivering hydrogen aviation's full potential for reducing climate change.[25]

Making zero emission flight a reality

> **“Multiple UK government departments, regulatory bodies and industry players have a role in ensuring co-ordination happens.”**

To commercialise ZEF in the UK, a three-pronged strategy is needed:

Unless all three elements come together in a co-ordinated way, ZEF uptake will be slower. Multiple UK government departments, regulatory bodies and industry players have a role in ensuring co-ordination happens.

We explore all three of these areas in more depth, including the policies that would make the UK a world hub for developing and adopting ZEF.

Aircraft development

The UK is well placed to lead on the global development of ZEF, given its expertise in engines, wings and fuel tanks, as well as its comparative advantage in aerospace advanced manufacturing and its strengths in research and development.[26,27,28] The prize of doing so and moving fast on hydrogen powered flight is big, with the potential to create an additional 38,000 aerospace sector jobs and £37 billion annual gross value added to the economy by 2050.[29]

Small and medium sized enterprises (SMEs) in the UK aerospace sector are leading the way, such as ZeroAvia, a US headquartered private company with a large UK presence, developing hydrogen engines for aviation. It announced a new manufacturing facility in Scotland in June 2025, creating 350 jobs.[30]

However, the funding environment is challenging for smaller companies developing hydrogen propulsion for passenger aviation, as highlighted by the recent pivot of the UK-headquartered Cranfield Aerospace Solutions to fixed wing cargo drones instead.[31,32]

Short term financial incentives for the large incumbents are also not well aligned with the need to make rapid progress towards ZEF. For example, Airbus has committed to developing a hydrogen fuel cell aircraft and has much of the required expertise in the UK, but it also has over 7,000 outstanding orders for its existing single aisle aircraft. Estimates of current production rates suggest they will take

> With long aircraft lifetimes, ZEF technologies need to be commercialised as soon as possible.”

around a decade to fulfil and order numbers for these aircraft remain strong, with over 600 placed in 2024.[33,34, 35]

The financial investment and risks involved in developing a new zero emission aircraft to replace Airbus’s existing, popular model are likely to weaken the business case for rapid ZEF development, in combination with slower than expected development of a UK hydrogen economy, despite the company’s climate commitments.

With long aircraft lifetimes of, on average, 22.5 years, ZEF technologies need to be commercialised as soon as possible.[36] A sizeable number need to enter the fleet by 2050 to help prevent the worst impacts of climate change as the aviation industry is only likely to be able to afford one fleet renewal by this date.[37]

The UK can position itself as a central location for the development and testing of zero emission aircraft, encouraging international companies into the country, helping to remove obstacles for testing and developing the skills and workforce to service ZEF.

Development of ZEF technologies requires patient capital. But the UK’s venture capital market (focused on frontier technologies still in development) and private equity market (focused on late stage scale up and mature technologies) skew towards investment in low capital intensive industries.[38]

To overcome this difficulty, in relation to developing ZEF, the government should align the missions of the forthcoming industrial strategy, National Wealth Fund, Aerospace Technology Institute (ATI), Innovate UK and British Business Bank. This should ensure there is sufficient finance across them to provide UK businesses at the cutting edge of ZEF with access to the patient capital needed to scale up their operations and commercialise.

The UK’s ATI, in particular, is a significant attraction for businesses considering where to base their headquarters, both in terms of the funding itself and the validating role grants play for private investors. If the government extended the committed funding for the ATI from five to ten years, with an explicitly defined percentage of its funding directed towards ZEF, it would provide businesses with longer term certainty to invest in the UK.

A further significant draw to the UK is the Civil Aviation Authority's hydrogen challenge sandbox, which is working collaboratively with industry, academics and the government on 13 projects to understand how hydrogen can be used safely for UK aviation.[39] It is funded by the Department for Transport on a rolling one year basis, which is limiting the breadth and speed of its work, despite its comparatively low funding needs. Moving to a three year funding cycle would signal a stronger intention to industry and investors that the UK has a framework to develop world leading ZEF.

> **"The government will have to act fast to attract businesses developing zero emission flight."**

The UK has many of components needed to lead in these technologies but other countries are also eyeing up the opportunities (see opposite). The government will have to act fast to attract businesses developing ZEF.

The UK's competitors

Japan, China, the US and Norway are going to present the UK with stiff competition in the race to be an early leader on ZEF.

With the explicit aim of making the country a leader in ZEF, the Japanese government has provided a $110 million grant to two companies developing hydrogen fuel cells for aviation, along with a commitment for a public-private joint investment of $26.46 billion over ten years to develop a hydrogen powered passenger aircraft.[40,41,42] Japan is already a leading nation in automotive hydrogen fuel cells.[43]

The UK government's primary funding for ZEF, by comparison, is via the Aerospace Technology Institute (ATI), which has £975 million for the period 2025-30.[44] But these funds are not exclusively for ZEF, they are also for businesses improving energy efficiency (including in the use of fossil fuels), developing cross-cutting enabling technologies and measures to understand and reduce aviation's non-CO_2 impacts.[45]

China dominates the production of many green technologies, including batteries, and is making progress on ZEF. A four seat battery electric aircraft has been certified for airworthiness, a 19 seat battery electric plane is being developed by Commercial Aircraft Corporation of China (Comac) and a four seat hydrogen combustion aircraft has made its maiden test flight.[46,47,48]

In the US, the Biden administration allocated a portion of its $369 billion Inflation Reduction Act package to the development of hydrogen and ZEF.[49] While the picture is less clear around the Trump administration's ongoing financial support, Heart Aerospace's relocation from Sweden to the US was due to better opportunities in Los Angeles, where its customers, partners and investors are increasingly based.[50]

Norway, while not a significant aerospace manufacturer, is adopting an approach designed to make it the desirable place to test zero emission technologies and develop airport infrastructure, bringing together the aviation regulator, airlines, manufacturers, suppliers and the energy sector.[51] It has established a ZEF test area with flights expected to take place between Stavanger and Bergen in the summer of 2025.[52]

Airport infrastructure

With hydrogen aircraft likely to enter commercial operation by 2030 and long lead times for infrastructure development, airports must prepare for the refuelling, systems and processes needed to service hydrogen powered flight.[53]

Different airports are likely to take different approaches to hydrogen generation, transportation and storage. Airports serving lower numbers of passengers could find it easier to balance space constraints than busier airports, for onsite hydrogen production via electrolysis and storage.

However, capacity for onsite hydrogen production will be dictated by how easy it is to connect to the electricity grid. For early stages of ZEF development, hydrogen production is likely to happen outside the airport and be transported in via trucks or pipelines. Although safety requirements will differ, technology to transport these fuels is similar to that which already exists, so will not be a barrier to ZEF for airports. Pipelines can take approximately five to seven years to build though, and longer when land acquisition and planning processes are factored in.[54]

As is the case with current onsite jet fuel storage, airports also need to consider hydrogen storage, to increase resilience to supply disruptions. Liquid hydrogen is likely to be the preferred choice due to the volume of gaseous hydrogen required for medium to large scale testing. Early hydrogen pilot programmes are likely to use flexible small

“The move to hydrogen flight, and requirements to service it, will present opportunities for airports.”

scale infrastructure which evolves as options for scalability and cost become clearer.

A small number of UK airports, such as Bristol and Exeter, have started to test hydrogen within the airport environment as a step towards adopting hydrogen planes.[55,56] The focus has been on fuelling ground support vehicles, such as a baggage tractor and pushback tugs. This is bringing together academics, industry and regulators to start developing a safety and regulatory framework and operational guidance. Dispenser vehicles to fuel the aircraft with hydrogen do not currently exist, though projections suggest they could be developed in three to five years.[57]

The move to hydrogen flight, and requirements to service it, will present opportunities for airports. Many have large tracts of land suitable for solar panels, including extensive car parking that could be fitted with solar canopies, generating renewable energy for onsite use to complement the electricity grid. Combined with long term plans for onsite hydrogen production and liquefaction, airports could become local energy hubs, fulfilling their need for cheap electricity while providing surplus electricity to the grid and hydrogen to local industry and businesses.[58]

Given the timelines and complexities involved, all airports should update their five year master plans soon to incorporate future hydrogen infrastructure and land use needs. The potential to become an energy hub should be taken into account, including engaging with the Strategic Spatial Energy Plan and Regional Energy Strategic Planners to ensure energy network planning across the relevant fuel types

Stimulating demand

For zero emission planes to fly, there needs to be a commercially attractive environment for airlines to rent or buy them.

There are positive signs that airlines want to fly zero emission planes. ZeroAvia has received over 2,000 pre-orders for its hydrogen fuel cell engines, predominantly from US headquartered airlines, Loganair and Ecojet, a new business looking to launch ZEF in the UK.[59] Among the main UK carriers, easyJet has committed to be an early adopter of the technology, British Airways has invested in ZeroAvia, and Logan Air has ambitions to deliver the world's first commercial ZEF route in the Scottish Highlands and Islands.[60,61,62]

But airlines are only prepared to pay a small premium for choosing and running zero emission aircraft in the short term and expect savings in the medium and long term.

As ZEF ramps up, for investors and the aerospace sector to be confident of a ready supply of cost competitive 'green' hydrogen in the UK in the 2030s the government must tackle the UK's high cost of electricity, which determines its price.[63]

> “The government should introduce a tax on kerosene used for domestic flights, reflecting its climate impact.”

The UK is targeting 10GW of hydrogen production by 2030, of which 6GW would be green hydrogen.[64] By 2035, our assumption is that production will need to increase to 70 terrawatt hours (TWh), the equivalent of 12GW of production capacity, to meet the other demands for it across the economy.[65] For half of all domestic flights to be zero emission, approximately 2.7 TWh of additional hydrogen per year will be required by 2040.[66] These figures combined are at the lower end of the government’s predictions for the 2030s, suggesting availability of hydrogen for aviation – at least at the national scale – should not be a concern if production progresses as expected.[67]

The price of hydrogen, including at any particular location, taking into account transport and storage costs, may be more of an issue. While the future price is uncertain, an estimate of unit cost across four European countries, including the UK, in 2040 is €3.78 per kilogramme. This includes production, distribution and liquefaction, which will be included in the final price paid by airlines.[68] It is equivalent to £81 per megawatt hour (MWh), against the average price for kerosene in Europe from refineries of £48 per MWh from May 2024 to May 2025.[69] While not a perfect comparison, as these are not the final prices that will be paid, this points to a potential difference in fuel prices that should be narrowed for hydrogen to be price competitive with other fuels.

As well as making every effort to cut the cost of green hydrogen, the government should introduce a tax on kerosene used for domestic flights, reflecting its climate impact. This should ensure that the tax, and carbon pricing in the UK’s emissions trading scheme, rise to a level consistent with the government’s valuation of the price of a tonne of carbon dioxide by 2035.[70] The absence of tax on aviation fuel is at odds with the polluter pays principle, a new kerosene tax would correct this and encourage the uptake of cleaner alternatives.[71]

Establishing a zero emission flight route by 2030

“Establishing the route will support the case for business investment.”

The government wants zero emission routes to be operating within the UK by 2030.[72] To set ZEF on this path, using the three-pronged strategy we have outlined, the government should establish a commercial route, aiming to use a 60 to 80 seat hydrogen plane by 2030.

With the introduction of new engines and airplanes, there is often unplanned downtime for maintenance and the same is likely to be true in this case.[73] The route will be a valuable testing ground to identify and resolve issues.

Establishing the route will create initial demand and support the case for business investment, and for airlines and airports to invest in hydrogen planes and infrastructure, showing that operating risks are manageable.

Having a start date would force rapid development of regulation, standards and associated industry expertise to service the trial and prepare for the adoption of hydrogen technologies. All of which could become valuable global exports for the UK.

Preparing for the route

> **For zero emission flights on the route, the government should zero rate Air Passenger Duty for five years.”**

To bring the route into operation, the government has a range of financial tools at its disposal. It should use the National Wealth Fund to provide low cost loans to the airlines or companies leasing planes to the route operator, so they can purchase zero emission aircraft from a UK manufacturer. The National Wealth Fund could also provide low cost loans to airports to develop hydrogen infrastructure.

For zero emission flights on the route, the government should zero rate Air Passenger Duty for five years, explore subsidised landing fees for the same period and provide support for staff training and development of hydrogen handling standards.

Given the importance of creating a ZEF route for both the economic opportunity and carbon reduction, the government should assess the financial viability of the route in 2028, employing the measures we have proposed, and introduce further time-limited subsidies, if necessary.

Although aviation should fund its own decarbonisation, given the barriers the route will help to overcome and the wider societal benefits from decarbonisation, a limited subsidy may be justifiable.

A Bristol – Glasgow – Belfast route

Low carbon innovation investment in the areas surrounding these airports generates relatively high economic returns, creating regional economic benefits and jobs across England, Scotland and Northern Ireland.[74]

A target for zero emission domestic flight

> “A 50 per cent target will provide certainty for businesses and investors.”

The Jet Zero Strategy aims for all domestic flights to be net zero by 2040, which can include offsetting the emissions from fossil fuel powered flight. It does not direct what proportion of these should be zero emission.

Given the potential UK economic benefits from being a world leader in ZEF technology, the government should spur investment in the UK’s aerospace and aviation sectors by setting a target for 50 per cent of domestic flights to be zero emission by 2040. This will provide certainty for businesses and investors around the UK’s long term commitment to developing ZEF technology, build on the progress made by the 2030 route and achieve meaningful greenhouse gas emissions reduction.

The Jet Zero Strategy’s high ambition scenario targets five per cent of UK domestic and international ‘air transport movements’ to be zero emission by 2040.[75] If half of all domestic flights were zero emission in 2040, this would be 11 per cent of all the UK’s air traffic movements.[76]

> **“It is imperative that co-operation to develop zero emission routes between the UK and other countries also continues.”**

This increase is ambitious but feasible. With the right framework, hydrogen fuel cell planes carrying up to 80 passengers on domestic routes should be commercial before 2030.[77]

Projections have been extended for achieving a narrow body hydrogen combustion plane, able to fly medium haul international routes. It does not look likely to happen now by the aspiration of 2035, making domestic flight progress all the more important.[78] A target focused on domestic flights ensures the government is not relying on the progress of international partners to meet its target. But it is imperative that co-operation to develop zero emission routes between the UK and other countries also continues.

Achieving 50 per cent zero emission domestic flights by 2040 could reduce the UK's total aviation emissions by 1.6 per cent compared to today, assuming the proportions of domestic and international flights remain the same in 2040 as today.[79]

Setting a target would benefit the UK's aviation sector and regional economies that host aerospace clusters. Rapid investment in hydrogen powered flight could secure almost a fifth of the global aerospace industry in the UK and generate around £37 billion gross value added per annum for the economy by 2050.[80] It could also provide 38,000 new jobs in the sector across the UK by this date.[81]

The target would also help to redirect the SAF available to long haul aviation, while ZEF technologies servicing medium and long haul routes continue to be developed. This will help the government achieve progress on reducing aviation's emissions for international routes, one of the hardest areas to decarbonise by 2050.

Securing the future of the industry

> **“Developing this sector would secure the future of the UK’s prestigious aerospace industry.”**

The UK could be a world leader in zero emission aviation. Developing this sector would catalyse investment, with huge export potential and secure the future of the UK’s prestigious aerospace industry for decades to come. It would also make real progress on reducing UK carbon emissions. To ensure a global position at the forefront of ZEF, the government should:

1. Set a target for 50 per cent of domestic flights to be zero emission by 2040.

2. Establish a ZEF route between Bristol, Glasgow and Belfast by 2030, including by:
   - providing low cost finance through the National Wealth Fund for the route for airlines to buy zero emission aircraft from a UK manufacturer and for airports to build the required infrastructure;
   - zero rating air passenger duty on the route for zero emission flights for five years.

3. Provide a well co-ordinated funding and innovation environment, by aligning the industrial strategy, National Wealth Fund and Aerospace Technology Institute (ATI) missions to focus aviation investment on zero emission technologies. Couple this with long term funding commitments for the ATI and Civil Aviation Authority’s Hydrogen Challenge.

4. Require airports to update their five year master plans to incorporate hydrogen infrastructure, consistent with a 2040 ZEF target.

5. Introduce a kerosene tax on domestic flights to ensure taxation and carbon pricing in the emissions trading scheme rise to a level consistent with the government’s carbon value by 2035.

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