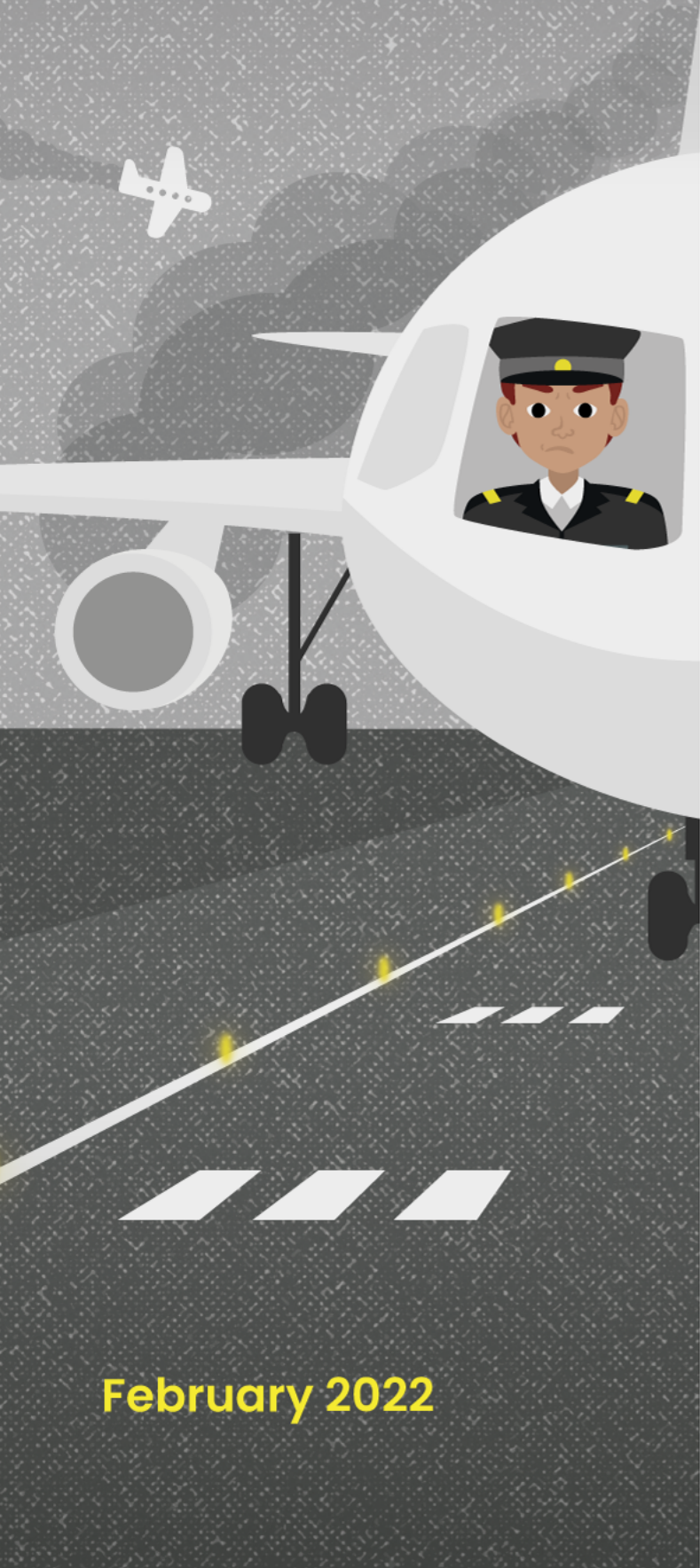


The Right Track for Green Jobs



February 2022

Cutting aviation emissions while boosting employment and climate-friendly travel



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Inspiring climate action

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Inspiring climate action

Possible is a UK based climate charity working towards a zero carbon society, built by and for the people of the UK. Our A Free Ride campaign aims to protect access to reasonable levels of flying for the less well-off, whilst maintaining aviation emissions within safe limits for the climate.

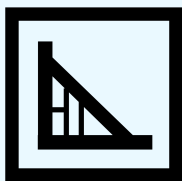
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Autonomy

Autonomy is an independent, progressive research organisation that focuses on the future of work and economic planning. Author James Meadway is an economist whose work has focused on democratic ownership, environmental economics, automation and the digital economy.

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Safe Landing is a group of climate-concerned aviation workers, including: pilots, cabin crew, airport staff, aerospace engineers and factory operators.

<https://safe-landing.org/>

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1. Executive summary

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All sectors of the UK economy must get their greenhouse gas emissions on a trajectory to as close to zero as possible to avoid contributing to dangerous levels of harm to the climate. Unlike sectors such as energy or surface transport, low-carbon alternatives are not available at scale for aviation, and won't become so for several decades at best. This leaves demand reduction as the key route to limit emissions from flying in line with the UK's national and international climate commitments. As most people rarely fly, there's scope to minimise the harm caused by aviation emissions by reducing frequent flying by the small number of people who take most of the flights.¹

While a significant reduction in flights compared to their pre-Covid peak could bring the UK's aviation sector into line with its climate commitments, this solution raises the question of how to avoid the potential negative impacts of reducing demand on both the travelling public and on people employed in aviation. The disruption to the aviation industry caused by the Covid crisis, along with industry's failure to prioritise protecting jobs, shows the harsh impacts on working people of an abrupt, unmanaged drop in demand without a plan in place to protect workers, or sufficient care for their jobs or livelihoods. However, even prior to the impacts of the Covid crisis on the aviation industry, it had a pattern of declining jobs supported per passenger, requiring ongoing demand growth in order to sustain employment. The loss of access to travel during Covid lockdowns also made clear the drop in people's quality of life when they lost the ability altogether to enjoy leisure travel, or visit family and friends in other countries.

It's clear that a solution to aviation emissions is needed which reduces the harm flying causes to the climate by reducing demand for flights, while also ensuring that people

¹ Leo Murray, *Proposal for a frequent flyer levy* (2015). Available at: <https://s3-eu-west-1.amazonaws.com/media.afreeride.org/documents/FFL+Policy+Proposal.pdf>

can still travel and creating good, green jobs. Any strategy for reducing aviation to protect the climate must also support people working in aviation – a sector with a long-term pattern of declining jobs supported per flight – who would like to move into a lower-emissions sector (or into the potentially emerging sector of decarbonised flight).

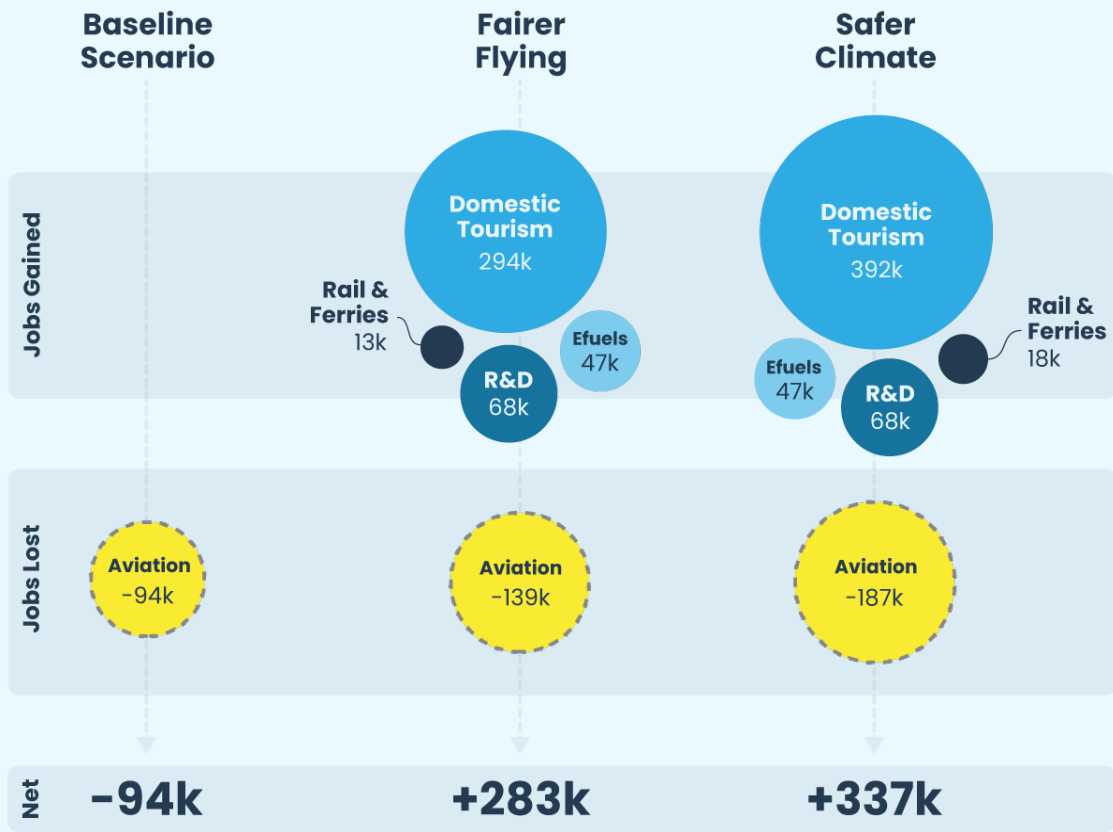
This paper finds that these goals could be achieved by a significant modal shift away from plane travel towards low emissions surface transport, along with an increase in domestic tourism and increased investment in potential pathways to lower emissions flights. These measures would also need to be accompanied by a funded right to retrain scheme for people working in high carbon sectors such as aviation, to provide support to ensure that they could transition to a suitable role in the low carbon economy and that their skills and experience would not be lost.

We explored two scenarios for a reduction in flights and a corresponding shift towards train travel – with one reducing flights by half and the other by two thirds while maintaining the same number of journeys overall – compared to a baseline scenario based on parameters for aviation demand from the Climate Change Committee’s “Balanced Net Zero” pathway in 2030.² Our scenarios also increased domestic tourism, and modelled a ramp-up in the use of alternative fuel to replace kerosene.

We found that in both these scenarios, potential new jobs created from the transfer of passengers to lower-emissions forms of transport can more than compensate for the jobs lost from aviation as a result of reducing demand. The jobs that could be created – in rail, low-emissions ferries, domestic tourism, and the research and development and cleaner fuels required to reduce emissions from flying – outweigh job losses in aviation by a factor of around three. In the scenario which reduced aviation by a half, around 140,000 jobs were lost and 420,000 jobs were created, generating a net increase in employment of around 280,000. In the scenario which reduced aviation by two thirds, around 185,000 jobs were lost and 525,000 created, providing a net increase in jobs of around 340,000.

² Climate Change Committee (2020). Charts and data from the Sixth Carbon Budget. Available at: www.theccc.org.uk/wp-content/uploads/2020/12/The-Sixth-Carbon-Budget-Charts-and-data-in-the-report.xlsb

Figure 1: Jobs lost in aviation and gained elsewhere under different levels of modal shift in travel habits away from flying, from 2020.



In the scenarios we explored, both of which represent very sizeable reductions in aviation emissions and a corresponding modal shift towards surface transport, around three jobs are created for each job lost in aviation. If the number of flights were halved, for every ten jobs lost in air travel around one would be created in surface based transport, five in R&D within the aerospace sector, 20 in tourism and three in the renewables capacity required to synthesise alternative fuels. Replacing flights with more climate-friendly ways of travelling creates many more jobs than would be available under a business-as-usual pathway for aviation.

Table 1: Jobs created per job lost in aviation under a modal shift to more climate-friendly modes of transport, and accelerated shift to low carbon aviation fuels.

Sector	Flights reduced by half	Flights reduced by two thirds
Rail and ferry	0.10	0.09
Research and development within aviation	0.49	0.36
Domestic tourism	2.11	2.10
Renewables capacity to create alternative fuels	0.34	0.25
Total	3.03	2.81

This demonstrates the potential for a transition to lower levels of aviation which prioritises maintaining people's ability to travel and protecting people working in the sector, to have an overall positive impact on job creation and the number of jobs available across the economy. Concern about the impact of reducing aviation demand on people working in the sector – many of whom have already experienced great hardship during the Covid crisis – is justified, and measures to support aviation sector workers, including a right to retrain, should be put in place urgently. **However, this study makes clear that, at the level of the UK economy, it is worse for job numbers, as well as for the climate, to maintain the pre-Covid status quo of high aviation emissions, frequently unaffordable train travel and a large tourism spending deficit.**

Replacement of the fossil fuel economy with clean, sustainable energy must be accompanied by a strategy to ensure that this improves people's lives and helps build a better future for everyone. **Creating good green jobs, and supporting people working in high-carbon sectors who want to move into these new roles, is a key requirement to maintain public support and enthusiasm for this transition.**

Our modelling suggests that there would be an annual cost in 2030 of around £9.5 bn in both these scenarios to develop

technologies to cut aviation emissions, and to provide retraining for people working in aviation who want to move into different roles. This amounts to an additional cost of just under £8 bn, when the government's current research and development spend commitment is discounted. This cost is of the same scale as the aviation industry's £7 bn exemption from fuel tax and zero-rating for VAT each year before Covid, and shows the scale of environmental and social benefits that could be achieved by directing aviation's tax breaks into more productive areas.

2. Policy recommendations



Reducing UK aviation emissions in line with our climate commitments requires the government to immediately introduce policies to discourage flying, particularly frequent flying, and ensure that climate-friendly ways of travelling are more affordable than flights. Without such measures, continued growth in demand for flights will eclipse projected emissions savings from technological advances. The following policies would fairly and equitably reduce emissions from aviation, and support the large-scale shift to lower-emissions modes of transport which is required to curtail aviation emissions.

- **Replace Air Passenger Duty with a progressive tax on flying, such as a frequent flyer levy or air miles levy, to discourage the frequent flying which causes the majority of UK aviation emissions. Genuinely low-emissions flights – e.g. using electric propulsion – should be exempted from the levy, to incentivise their development.**
- Introduce and fund a right to retrain scheme for people working in aviation who would like to move to a lower-carbon sector.
- Increase support for train travel to improve its affordability and accessibility.
- End the tax exemption on jet fuel, as the European Commission has recently proposed in the EU, and end the 0% rating for VAT.
- Ban frequent flyer reward programmes, which encourage excessive flying.³
- End domestic flights for which there is a viable low-carbon alternative route.
- Assess the energy needs of electric alternative fuels (e-fuels) and put in place a plan to deliver the substantial additional renewables capacity which they would require in order to scale.

³<https://stay-grounded.org/frequent-flyer-programmes-incentivise-climate-destruction/>

- Invest the increased tax revenue from air travel in alternatives, including improved domestic and international rail travel to key destinations, and in retraining and support for people working in the aviation sector.
- Align the total tax take on aviation powered by kerosene with the goal of addressing the price gap between synthetic fuels and fossil fuels.

3. Introduction



The need for urgent action to tackle the climate crisis has never been clearer. The impacts of extreme weather on people around the world are seldom far from the headlines, and scientists warn that very few years remain to cut emissions sufficiently to limit warming to 1.5 degrees. All sectors must, therefore, play their part in rapidly constraining emissions to as close to zero as possible. This must include aviation – a high-emitting sector for which the benefits are very unevenly distributed, yet one that cannot be decarbonised by the technologies that are currently available. Allowing aviation emissions to increase for years or even decades, with the hope that technofixes will emerge just in time for reductions by 2050, is simply not a strategy that's fair to people who are already suffering the harms of a rapidly warming world.

Before the pandemic, aviation accounted for 7% of UK greenhouse gas emissions, with emissions from the sector having increased by 88% since 1990.⁴ Yet just 15% of people in the UK take 70% of all the flights, while around half of people don't fly at all each year.⁵ This unequal distribution presents a clear opportunity to significantly reduce emissions from flying by reducing demand and transferring journeys to train travel, with little impact on the majority of people who already fly rarely.

This report explores three scenarios for the UK aviation industry over the current decade to 2030, based on increasingly ambitious emissions reductions targets. Aviation has been one of the sectors worst affected by the Covid-19 pandemic, with severely restricted passenger numbers for the past 18 months following restrictions on travel by governments and changes – potentially permanent – in the pattern of consumer demand. This moment of change presents an opportunity to prevent future levels of aviation returning to environmentally unsustainable pre-pandemic

⁴ Climate Change Committee (2020). *The Sixth Carbon Budget: Aviation*. Available at: www.theccc.org.uk/wp-content/uploads/2020/12/Sector-summary-Aviation.pdf

⁵ National Travel Survey. Available at: www.gov.uk/government/collections/national-travel-survey-statistics

levels. If the sector is permitted to resume its former growth trajectory, its contribution to global greenhouse gas emissions levels will expand hugely over subsequent decades, threatening achievement of the UK's net-zero goals and the Paris Agreement temperature limits.

There are currently no viable alternatives to fossil fuel propulsion systems on the near-to-medium term horizon for commercial mass travel, particularly for longer journeys. Genuinely lower emission alternative fuels are the only plug-and-play option, and these are in their infancy, with total current production volumes equivalent to less than 0.05% of global jet fuel demand,⁶ and major – perhaps insurmountable – barriers to scaling above low single figure percentages. The only workable route to reducing aviation emissions within the timeframes required by our climate change commitments is therefore to reduce the demand for flights: switching passenger transport to alternative, lower-emission modes, or reducing demand for travel overall. The pandemic has already shown that this is possible, with international business travellers switching en masse to online meetings⁷ and a relative increase in UK domestic tourism.⁸

Our previous research found a willingness among travellers to move away from planes: two-thirds of people would consider travelling without flying at least some of the time, if the price difference between train and plane travel (caused by the generous tax breaks for aviation, along with externalising the costs of the harm it causes to the climate) were resolved.⁹

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<https://theicct.org/sites/default/files/publications/Sustainable-aviation-fuel-feedstock-eu-mar2021.pdf>

⁷ Zoom meeting participants globally increased from 10m daily in December 2019 to 300m daily in April 2020. Not all of this will be commercial use, but Gartner forecasts that only 25% of business meetings will return offline by the end of 2024. Karl, K. A., Peluchette, J. V. and Aghakhani, N. (2021), 'Virtual Work Meetings During the COVID-19 Pandemic: The Good, Bad, and Ugly', Small Group Research. doi: 10.1177/10464964211015286.

⁸ "In the South West of England, occupancy increased from 19% in April 2020 to 72% in August. No other English region exceeded 58% occupancy after March 2020, indicating that this region experienced closer to a "normal" summer season than any other in 2020, and is likely to have been the result of a relative increase in domestic tourism." ONS (15 February 2021), "Coronavirus and the impact on the UK travel and tourism industry". At:

www.ons.gov.uk/businessindustryandtrade/tourismindustry/articles/coronavirusandtheimpactontheuktravelandtourismindustry/2021-02-15

⁹ Possible and Survation (2021). *Fare Competition: A route to climate-friendly travel choices*. Available at: www.wearepossible.org/s/Fare-Competition_-_A-route-to-climate-friendly-travel-choices.pdf

However, for people who work in aviation the implications of constraining demand are concerning, increasing the threat of job losses in a sector in which employment is already insecure. **As the UK decarbonises its economy, protecting workers in high-carbon industries such as aviation from negative impacts must be a priority.** Introducing a right to retrain and economic protection while moving to a new sector for such workers would bring multiple benefits. It would ensure their continued livelihoods and the associated local and national economic benefits, as well as improve social cohesion and maximise public support for measures to rapidly reduce emissions. It would also ensure that these workers' important skills are not lost but can be maintained and enhanced in the low-carbon sectors, such as clean transport and renewable energy, which will need to greatly expand in the coming decades.

This paper finds that potential job losses from reducing levels of aviation can be more than offset by the creation of new jobs which support the transition to more climate-friendly modes of travelling. These include the creation of new jobs outside the aviation industry, along with jobs created by the application of new technologies within aviation – albeit with a shifting balance between the air travel and aerospace sectors. These results demonstrate the potential to transform the UK's transport system in a way which protects both workers and the climate. Government action and industry cooperation would be required to achieve the policies needed to rapidly reduce emissions from flying, while supporting a shift away from plane travel and towards more climate-friendly ways of travelling.

4. Three scenarios for aviation in 2030



We modelled two scenarios for ambitious reductions in aviation and a corresponding modal shift to lower-emission modes of travel over the eight years to 2030, along with a baseline “business as usual” scenario for comparison. The 2030 date was chosen due to the need to tackle aviation emissions now, rather than kick this problem into the long grass of 2050. **Both scenarios explore ambitious reductions in aviation demand and emissions compared to the baseline scenario, in order to stress-test the potential impacts on employment of a sizeable reduction in levels of flying to protect the climate.**

Scenario 1: Baseline

This scenario would see aviation emissions of 33 Mt CO₂e (million tonnes of carbon dioxide equivalent) and 285 million UK terminal passengers in 2030. For comparison, in 2019 aviation emissions were 39.6 MtCO₂e and there were 297m terminal passengers. This scenario is derived from the Climate Change Committee’s “Balanced Net Zero” pathway in 2030.¹⁰ This pathway models the economy-wide changes needed for the UK to reach net zero by 2050, while allowing aviation a generous emissions budget on the assumption that negative emissions technologies will emerge to balance the books.¹¹ This scenario therefore represents the absolute minimum the UK must do to fulfil its obligations to tackle the climate crisis, along with a sizeable gamble on the development, spread and affordability of a technology which is currently untested at scale. In this scenario, we assume that 2019 ratios of international and domestic flights, short and long haul flights and inbound and outbound travel are maintained.

¹⁰ Climate Change Committee (2020). Charts and data from the Sixth Carbon Budget. Available at: www.theccc.org.uk/wp-content/uploads/2020/12/The-Sixth-Carbon-Budget-Charts-and-data-in-the-report.xlsb

¹¹ Climate Change Committee (2020). *The Sixth Carbon Budget: The UK’s path to Net Zero*. Available at: www.theccc.org.uk/wp-content/uploads/2020/12/The-Sixth-Carbon-Budget-The-UK-s-path-to-Net-Zero.pdf

Scenario 2: Fairer Flying

50% reduction in flights

This scenario is based on our proposal for a frequent flyer levy to manage overall levels of aviation while more equitably distributing remaining flights,¹² along with National Travel Survey data on the number of flights people take each year.¹³ This data shows that, if people who typically fly more than once per year cut back to just one flight per year, that would cut the overall level of flights by more than half (just 43% of flights are people's first flight per year, with the remaining flights being taken by people who have already flown at least once). This would allow some expansion of access to air travel to people who do not currently fly, while reducing overall levels of flying by half – and not requiring people who only fly once per year to give up their annual holiday. This scenario decreases flights and tailpipe emissions by half in 2030, compared to the baseline scenario. Half of the remaining flights are powered by e-fuel in this scenario.

Scenario 3: Safer Climate

67% reduction in flights

This scenario is based on some parameters from the Centre for Alternative Technology's Zero Carbon Britain report, and aims to achieve a greater modal shift and more ambitious emissions reductions to protect the climate.¹⁴ Our scenario sees levels of aviation fall to a third of those in the baseline scenario, while fuel usage falls to just one quarter of the requirement in the baseline scenario due to greater incentive for efficiencies in a world with tighter emissions constraints. All of the remaining flights are powered by e-fuel in this scenario.

All three scenarios assume – as the aviation industry acknowledges¹⁵ – that electric or hydrogen powered planes

¹² New Economics Foundation (2015). *Managing aviation passenger demand with a frequent flyer levy*. Available at: <https://s3-eu-west-1.amazonaws.com/media.afreeride.org/documents/FFL+Modelling+paper.pdf>

¹³ National Travel Survey Q0316. Data is collected in England only. Available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/905946/nts0316.ods

¹⁴ Centre for Alternative Technology (2019). *Zero Carbon Britain: Rising to the Climate Emergency*. Available at: <https://cat.org.uk/download/35541/>

¹⁵ Sustainable Aviation (2020). *Decarbonisation road-map: A path to net zero*. Available at:

will not be available for commercial mass transit by 2030. They also do not rely on negative emissions technologies or greenhouse gas removals, which will not be available by this time even if they do eventually scale up to some extent. We make very generous assumptions about the scale-up and viability of e-fuels (lower-emissions fuel made by using renewable energy to capture carbon from the air and combine it with green hydrogen created by splitting molecules of water), with e-fuels providing half the fuel needed in the Fairer Flying scenario and all the fuel required in the Safer Climate scenario. Use of e-fuels can reduce, although not eliminate, greenhouse gas emissions from flying, with some non-CO₂ emissions likely to remain, so even the Safer Climate scenario does not create a zero emission aviation sector.

The Fairer Flying scenario uses half of the fuel required in the baseline scenario, and the Safer Climate scenario one quarter. If all three scenarios were to use only kerosene, then the Fairer Flying scenario would cut carbon emissions by a half and the Safer Climate scenario by three quarters, compared to the baseline. However, both of the more ambitious scenarios make use of e-fuel, a technology currently at a very early stage of development with the potential to greatly reduce or close to eliminate CO₂ emissions from flying at the systems level. While CO₂ is still emitted by planes using e-fuels, the atmospheric concentration of carbon is not increased due to the use of atmospheric CO₂ as the fuel's feedstock, making e-fuels (close to) carbon neutral overall. In addition, e-fuels may also be able to reduce the non-CO₂ emissions of aviation, such as contrail cirrus clouds, which are produced by burning kerosene. Research suggests potential total warming reductions of between 30 and 60% from e-fuels.¹⁶ This means that, in addition to reducing the carbon impacts on the climate from flying, the use of e-fuels is also likely to reduce, although not eliminate, the harm caused to the climate by the non-CO₂ impacts of flying.

https://www.sustainableaviation.co.uk/wp-content/uploads/2020/02/SustainableAviation_CarbonReport_20200203.pdf

¹⁶ Fuel Cells and Hydrogen Joint Undertaking (FCH) (2020). *Hydrogen-powered aviation: A fact-based study of hydrogen technology, economics, and climate impact by 2050*. Available at: https://www.fch.europa.eu/sites/default/files/FCH%20Docs/20200507_Hydrogen%20Powered%20Aviation%20report_FINAL%20web%20%28ID%208706035%29.pdf

In both the scenarios with more ambitious reductions in aviation demand and consequent emissions, we used 2019 patterns of short and long haul travel between the UK and other countries, both for outbound visits from the UK and inbound travel from other countries to the UK, to explore the potential for a modal shift. This included modal shifts of some short-haul journeys from planes to train or ferry journeys, as well as a transfer of some long-haul flights to shorter journeys which could be made without flying. We also included a shift from international to domestic tourism for some outbound journeys made by UK residents. Half of the new train journeys which replace some outbound flights by UK residents were replaced by domestic rather than international surface transport journeys, with the remaining half of lost flights replaced by international journeys by lower emission forms of transport. Journeys moving from international to domestic travel amounted to 24% of outbound journeys or 13% of total journeys in the Fairer Flying scenario, and 31% of outbound journeys or 17% of total journeys in the Safer Climate scenario.

In all three scenarios the total number of journeys remains the same, and only the proportion of flights which are replaced by lower-emissions modes of transport or moved from longer to shorter journeys varies.

See Appendix A for full numbers on the journeys made in the three scenarios.

5. Covid-19 and aviation employment



The Covid-19 pandemic seriously affected aviation, as passenger numbers collapsed across the world. UK-domiciled airlines received a very large amount of taxpayer-backed support, with the aerospace industry receiving £12bn from the UK government over the course of the pandemic.¹⁷ This included £750m from the Coronavirus Job Retention Scheme, which aimed to protect employment through the Covid crisis.¹⁸ Despite this, airlines including the UK flag-carrier British Airways attempted to push through mass redundancies and pay reductions while in receipt of job retention scheme funding, which attracted cross-party criticism in Parliament and opposition from trade unions representing workers in the sector.¹⁹ **It was clear that protecting employment was not airlines' priority during Covid, with some also attempting to use the crisis to "fire and rehire" workers onto poorer pay and conditions.**²⁰

Unite estimates that 46,247 UK aviation jobs were lost between February 2020 and the early months of 2021.²¹ This is somewhat worse than the early forecasts made by the New Economics Foundation, on the basis of airline company announcements, of 39,000 short-term job losses.²² Including ground crews and airport workers raises the total sector job losses to "at least 54,110", according to Unite.

¹⁷ Hansard, 18 October 2021, <https://questions-statements.parliament.uk/written-questions/detail/2021-09-21/52408>

¹⁸ Hansard, 26 January 2022, <https://questions-statements.parliament.uk/written-questions/detail/2022-01-18/106811>

¹⁹ www.unitetheunion.org/news-events/news/2020/may/ba-betrayal-campaign-alerts-british-airways-customers-and-partners/

²⁰ www.mirror.co.uk/money/major-companies-imposed-brutal-fire-24133539, www.eurocockpit.be/news/hall-shame-snapshot-new-anti-crew-practices-emerging-during-covid19

²¹ Acuity Analysis (17 March 2021), "Final call for UK aviation?", London: Unite the Union, p.11. At: <https://www.unitetheunion.org/news-events/news/2021/march/final-call-for-aviation-support-5-164-aviation-jobs-lost-every-month-as-industry-forgotten-by-government/>

²² Chapman, A. and Wheatly, H. (June 2020), *Crisis Support to Aviation and the Right to Retrain*, London: New Economics Foundation. At: <https://neweconomics.org/uploads/files/aviation-workers.pdf>

Towns and urban areas heavily dependent on aviation, such as Crawley and Slough, still had a high take-up of the government's furlough scheme in summer 2021, with participation remaining in double digits even as it fell sharply elsewhere.²³ As the Centre for Cities notes, these areas may see sharp increases in their unemployment rate as the furlough scheme is wound down while the Covid crisis remains.

The long-term impact of Covid on the aviation sector is difficult to determine. Ernst & Young suggested a range of different possibilities, including potentially permanent changes in the structure of demand and costs faced by the industry, with passenger numbers essentially never recovering.²⁴ **However, even if passenger numbers were to fully recover from the impacts of Covid, this does not equate to a full recovery in employment levels. The aviation industry has a long-term pattern both of declining employment intensity per passenger, and of the recovery of jobs numbers lagging behind passenger numbers following a demand shock.**²⁵ On the basis of existing trends in aviation productivity, with the number of jobs per passenger carried dropping continually over the previous two decades, the New Economics Foundation estimates that five years of stagnant demand for travel would produce 17,000 permanent job losses.²⁶

Recent forecasts from Airports Council International suggest that it could take up to two decades for passenger numbers to return to pre-Covid projected levels.²⁷ The International Civil Aviation Organisation (ICAO) has offered three future scenarios: in the most "optimistic", a rapid global economic recovery delivers a relatively quick return to pre-Covid levels of aviation demand by 2021; but in both its "central" and "pessimistic" scenarios, aviation recovery lags a slower general economic recovery, with future growth permanently lower than pre-Covid.²⁸ The UK's Climate Change Committee,

²³ Rodrigues, G. (29 July 2021), "What do the latest furlough statistics tell us about labour markets in the UK's largest cities and towns?", Centre for Cities blog. At: <https://www.centreforcities.org/blog/the-latest-furlough-statistics/>

²⁴ Ernst and Young (July 2021), *How does the airline industry brace for an uncertain recovery?*, London: E&Y, p.4

²⁵ <https://neweconomics.org/uploads/files/aviation-workers.pdf>

²⁶ *ibid.*

²⁷ Airports Council International (14 July 2021), "The impact of COVID-19 on the airport business and the path to recovery", Advisory Bulletin. At: <https://aci.aero/news/2021/07/14/the-impact-of-Covid-19-on-the-airport-business-and-the-path-to-recovery-2/>

²⁸ ICAO (June 2021), "Post-Covid19 forecasts scenarios", Table A. At: <https://www.icao.int/sustainability/Pages/Post-Covid-Forecasts-Scenarios.aspx>

as part of its preparation of the UK's Sixth Carbon Budget at the end of 2020, attempted to provide some scenarios for likely future passenger demand, based on consultation with the industry and experts. These scenarios do not expect passenger demand to fully recover before 2024.²⁹

Permanent reductions in demand are more likely to remain for business travel than for other sources of demand for flights. Recent surveys suggest that the decline in business travel since the pandemic began is likely to substantially remain in place, as the cost – and time – savings of teleconferencing have become more apparent.³⁰ In some of the CCC's scenarios, they estimate that half of business travel may not return by 2024, resulting in only 90% of pre-Covid passenger forecasts being met by that point. This matches the ICAO's "central" and "pessimistic" scenarios in the short-run, but the ICAO extends the analysis to suggest that, in both situations, demand growth never recovers to its pre-Covid levels.

It is therefore clear that the level of recovery of aviation passenger numbers will remain uncertain for some time, but even under optimistic assumptions about resilience of demand in the face of Covid the recovery in aviation jobs is expected to lag significantly. It is also likely that at least some part of the behavioural changes and new costs arising from the first years of the pandemic will lead to permanent changes in the economics of flying.

If, therefore, we treat the CCC's short-term 90% demand recovery as permanent, at least over the duration of our modelling period to 2030, and occurring regardless of future government policy on travel, or future changes in the public health situation regarding Covid, many of the current job losses in aviation are also likely to become permanent.

Mass redundancies in the aviation sector, if they are not accompanied by a strategy to support impacted workers to re-enter the workforce at an appropriate level, cause severe adverse impacts on those workers personally, financially and professionally. Their lives are disrupted, their economic contribution greatly reduced and their skills under-utilised.

²⁹www.theccc.org.uk/wp-content/uploads/2020/12/Sector-summary-Aviation.pdf

³⁰ Delaney, K.J. (31 July 2021), "This could have been a Zoom meeting: companies rethink travel", *New York Times*. At: <https://www.nytimes.com/2021/07/31/business/business-travel.html>

For example, following closure of Rolls-Royce's Renfrewshire aerospace engineering plant in 2020, almost two-thirds of workers were left out of work, and only 14% of those who had secured a new role were using their full range of skills.³¹ Only one in five reported being hopeful for their future employment prospects. **The contraction of high-carbon sectors such as aviation, which is required to tackle the climate crisis, must therefore be accompanied by measures to support people working in those sectors into roles which make best use of their valuable skills and experience, and protect their livelihoods and wellbeing.**

³¹www.unitetheunion.org/news-events/news/2020/october/new-research-finds-vast-majority-of-rolls-royce-inchinnan-workers-have-not-found-re-employment-as-union-demands-government-support/

6. Forecasting future employment



Our employment model utilises the relationship between the number of passengers carried by different modes of transport, and the number of jobs this supports. We assume that for any given level of demand, the industry seeks to maximise efficiency and minimise staffing costs, and the ratio of the number of passengers carried to the number of jobs required to do so is therefore determined by the technology available at the time. This allows us to predict the likely course of future job changes, given shifts in passenger demand.

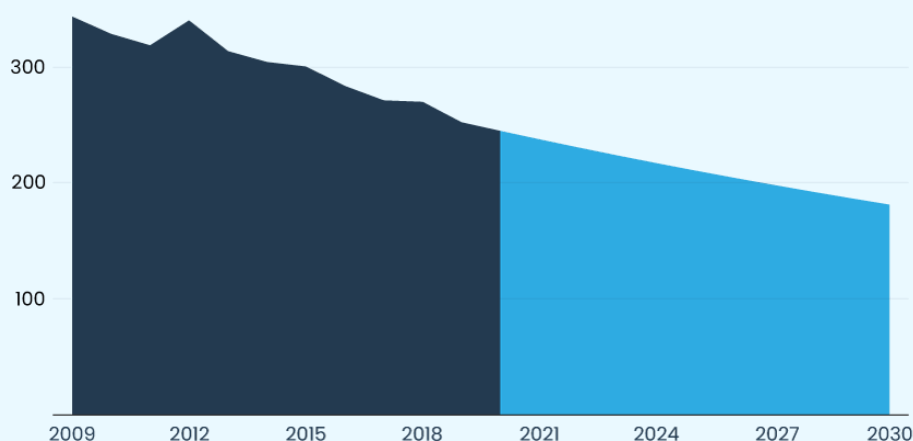
We consider this relationship in the five industries that will be central to any plan for ambitious emissions reduction for the UK aviation industry: air travel itself, rail transport, ferry transport, aerospace research and development (R&D), domestic tourism and renewable electricity generation (which would require a substantial increase if there is an accelerated shift from conventional fuels to e-fuels). The factors which drive job loss or creation in each of these sectors are crucial in determining the balance of net job losses or gains over the whole period: a decrease in levels of a relatively capital-intensive industry, such as aviation, along with an increase in one that is far more reliant on labour, such as domestic tourism, can result in sustained net job creation even with greatly reduced levels of aviation.

We also consider the progress of technological change within the air travel industry itself, which has tended to reduce the number of jobs required to transport any given number of passengers. Employment has been maintained (and even expanded) only because demand for air passenger travel has grown so much that it has more than counterbalanced the decreasing number of jobs required to transport a given number of passengers. The graph below illustrates this process for aviation employment (excluding ground staff and supply chain impacts).³²

³² This corresponds to the ONS' Standard Industrial Classification (SIC) code 51.

Figure 2: The number of jobs supported in aviation per million passengers over time.

The number of aviation jobs supported per million passengers is on a trajectory of decline, which is **forecast to continue**



Source: Office for National Statistics, Business Register and Employment Survey; Civil Aviation Authority, "Passenger Numbers"; Autonomy's own calculations.³³

Assuming that a profit-maximising aviation industry will continue to use technological development to minimise labour costs for any given level of demand allows us to assess baseline employment from future projected demand. We use a separate rate of change for ground staff and the wider aviation sector, relating to both international and domestic arrivals as separate series. This is because while airline staff numbers will change with passenger demand regardless of where the demand is coming from, ground staff numbers are likely to be affected differently by arrivals from different sources. A sharp decline in domestic departures, for example, may still require significant ground staff employed if high numbers of international passengers continue to arrive.

The steady reduction in employment intensity per passenger suggests that even if passenger demand were to recover from the shock of the Covid crisis, aviation employment is likely to remain lower than in 2019. Following the (smaller, but still significant) shock of the 2007–8

³³ ONS (6 November 2020), "Industry – 2, 3, 5 digit SIC, Business Register and Employment Survey", Table 2. At: <https://www.ons.gov.uk/employmentandlabourmarket/peopleinwork/employmentandemployeetypes/datasets/industry235digitbusinessregisterandemploymentsurveytable2>. Civil Aviation Authority (19 March 2021), "Aviation 2020: data". At: <https://www.caa.co.uk/News/Aviation-2020--Data-summary/>

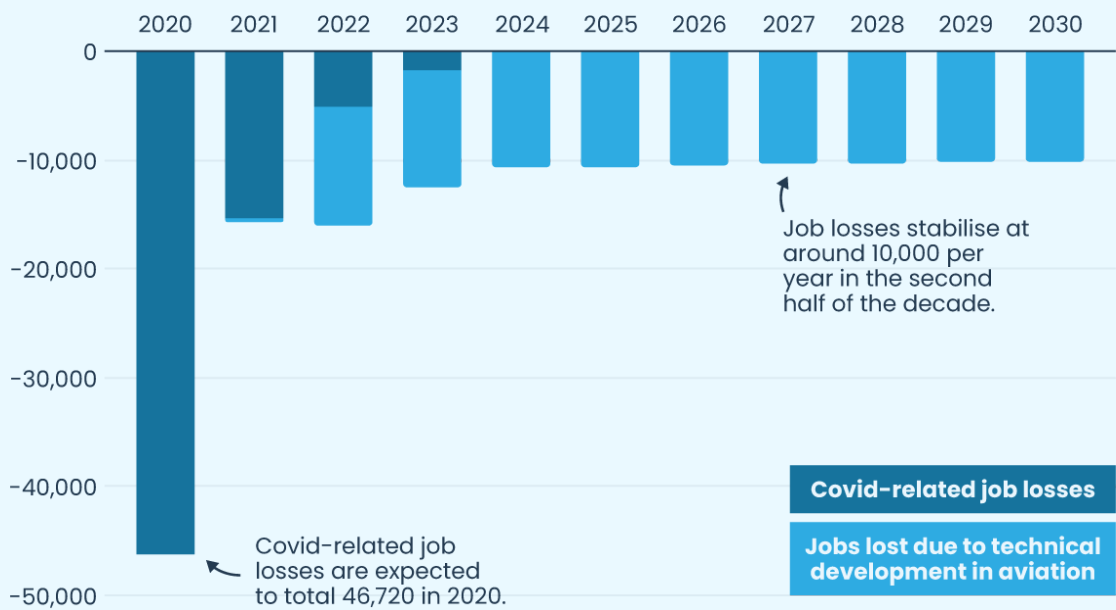
financial crisis, “passengers numbers took around seven years to return to their pre-crisis level, but at that point (2014) job numbers remained 17% below their pre-crisis peak.”³⁴ The far larger shock of Covid-19, with a longer recovery period to (potentially) a permanently lower level of demand, is likely to lead to a significant reduction in the industry headcount. It has been only the dramatic growth in demand over the previous two decades which sustained job creation in UK aviation; our proposal to cut emissions by reducing demand while protecting jobs needs to be seen in this context. Across the EU as a whole, employment in aviation fell by 7% from 2000 to 2013, even as passenger numbers grew.³⁵ Current business models in aviation do not prioritise sustaining employment, with workers seen as an overhead to be reduced rather than a valuable resource to be retained.

If we take the Climate Change Committee passenger demand projections as a baseline, and assume no further changes – allowing the same rate of technical progress over the last decade to continue into the next, and assuming profit-maximising airlines and other operators respond to lower costs per passenger by cutting staff – we forecast 19,000 job losses in aviation by 2030 (6%) if Covid-19 is a temporary shock, or 94,000 job losses by 2030 (31%) if Covid-19 provokes a permanent reduction in demand, as noted above. This is our baseline expectation for the future of the aviation industry in the UK: a substantial contraction on previous employment, driven by the long-term impact of Covid-19, changing demand for flying as a result of slowly tightening national emissions budgets, and continued technological developments which reduce staff requirements.

³⁴ Chapman, A. and Wheatly, H. (June 2020), *Crisis Support to Aviation and the Right to Retrain*, London: New Economics Foundation, p.17 At: <https://neweconomics.org/uploads/files/aviation-workers.pdf>

³⁵ Steer Davies Gleeve (October 2015), *Study on employment and working conditions on air transport and at airports*, Brussels: European Commission, p.50. At: <https://ec.europa.eu/transport/sites/default/files/modes/air/studies/doc/2015-10-e-employment-and-working-conditions-in-air-transport-and-airports.pdf>

Figure 3: Aviation job losses are expected to continue to 2030.



From this baseline, we will show how the two higher ambition scenarios for decarbonisation can sustain employment inside and outside of the existing aviation sector.

7. Views of people working in the industry



Disruption to aviation employment during Covid demonstrates the harsh impacts experienced by workers during an unmanaged transition, in which people can be left with no job and little support following years or decades of work in the aviation industry.³⁶ **While demand for aviation must be managed downwards in the decades to come to protect the climate, this must be accompanied by measures to protect people working in the industry from unemployment. We are therefore calling for a right to retrain for people working in high carbon sectors such as aviation who would like to move into a different sector (or to a developing sector of lower emissions aviation), to help them obtain alternative roles in which they can utilise their skills and experience.**

We carried out an online survey of more than 1,000 people working (or formerly working) in the aviation industry from December 2020 to March 2021, including flight and cabin crew, engineers and ground crew, and people employed across the aviation industry.³⁷ This explored how the Covid crisis affected them, how they feel about the security of employment this sector offers them for the future, whether they are seeking employment outside aviation and what support they would need to move into a different sector. At that point, 40% of respondents had been furloughed, 27% had had their hours or pay cut and 19% had lost their jobs.

69% reported an increase in anxiety or stress due to the effects of the Covid crisis on the aviation industry, and 62% a reduction in income. 48% experienced a reduction or loss of job security, 32% an increase in debt or financial insecurity, and 30% worsened working conditions. Just 6% had not experienced any impacts. This shows the clear personal, professional and financial harm which workers

³⁶www.unitetheunion.org/news-events/news/2020/october/new-research-finds-vast-majority-of-rolls-royce-inchinnan-workers-have-not-found-re-employment-as-union-demands-government-support/

³⁷ This data was collected by survey with recruitment via various means, principally adverts on Facebook but also outreach to unions representing people working in aviation and online forums for these workers. Data has been rounded to the nearest whole percent.

suffer in an unmanaged transition, without sufficient measures in place to protect livelihoods or support re-employment.

Anxiety about the security of their employment in the aviation sector in the future was widespread among respondents. Just 21% of respondents thought that the aviation industry offered them secure employment for the future, with 29% thinking that the industry didn’t offer them secure employment for the future and 49% unsure whether their future employment in the industry would be secure.

Most respondents expressed concern about the impacts of the need to tackle climate change on employment in aviation. 34% were slightly concerned about this and 23% very concerned, with just 21% not concerned. 12% thought that the need to tackle climate change might have a positive impact on aviation sector employment.

Figure 4: Respondents’ answers to whether they were seeking alternative employment.

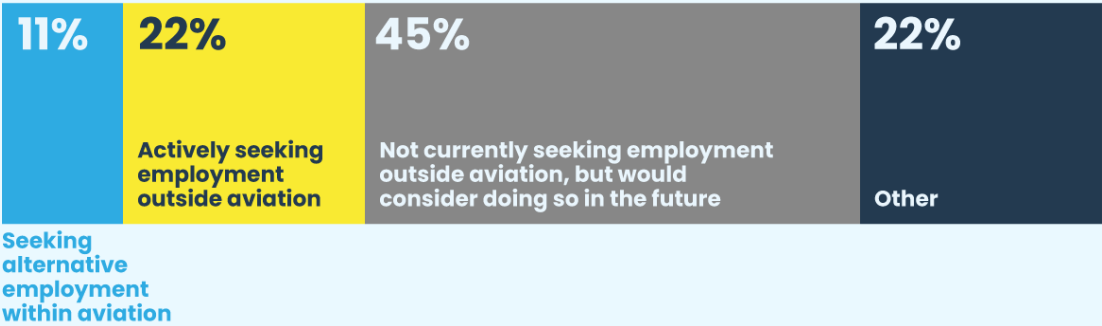
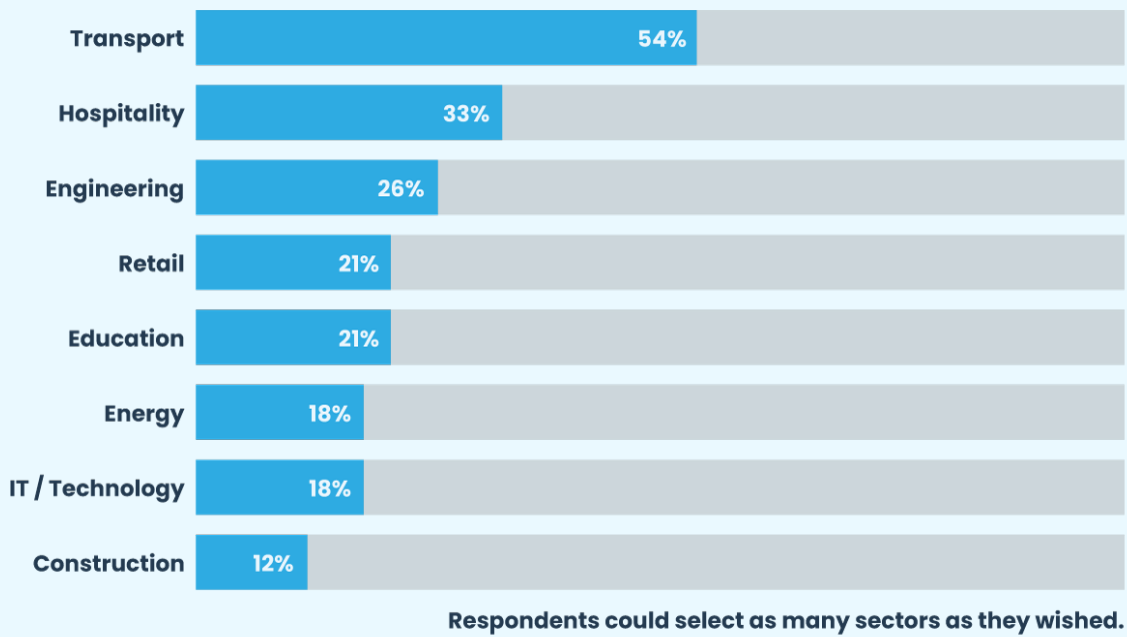
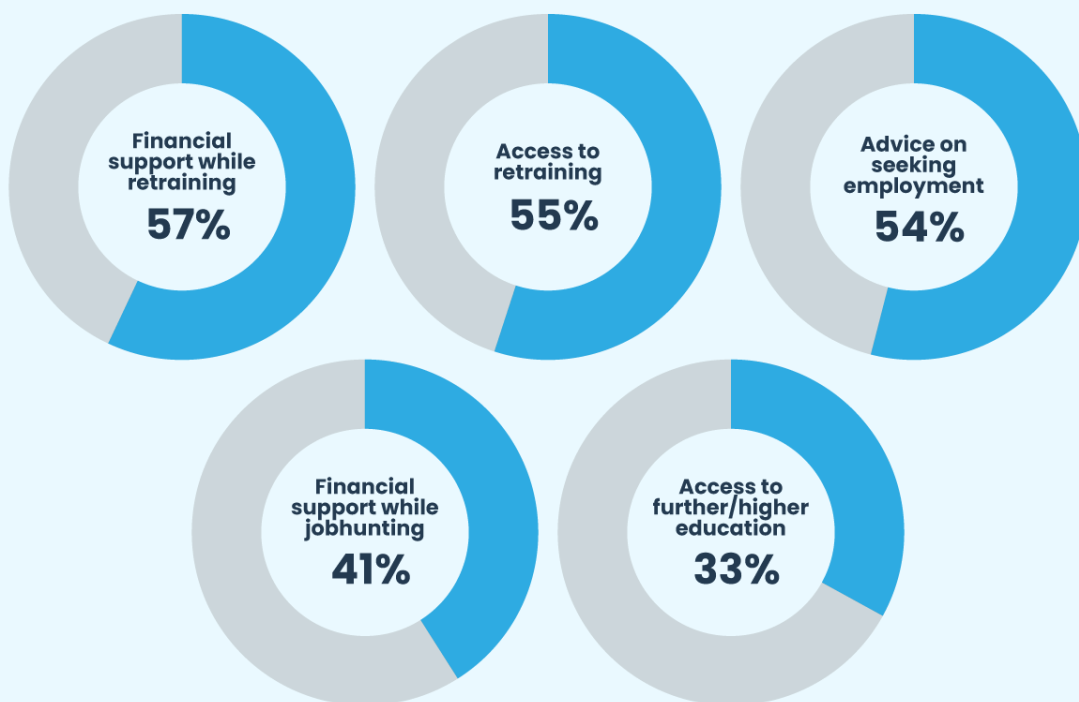


Figure 5: Respondents’ answers to which sectors they would look to move into if they were to seek employment outside the aviation industry.



The most important factor respondents would consider in seeking alternative employment was the level of pay (chosen by 74%), followed by job security (52%), working hours (45%) and working conditions (37%), being able to use their skills and experience (34%), and being able to have a positive impact on society or the environment (18%) - which was more important to people than level of seniority (6%) (respondents could select up to three factors).

Figure 6: Access to financial support and retraining were viewed as the most important support in moving into another sector.



Respondents could select as many factors as they wished.

This initial sample of the aviation workforce suggests that, while there is a lot of affection for the industry and for flying among people working in the sector, there is also significant anxiety about the security of their employment which pre-dated but was worsened by the Covid crisis. This snapshot of the views of a relatively small sample of workers in a large industry was taken at a time when the Covid-19 crisis was at its peak, and air travel had virtually ground to a halt. We suggest that further research is needed to provide a more in-depth and ongoing picture of the views of people working in aviation on the sector's future, and the support which people who would like to move into a role in a lower-emissions sector would need to enable this.

Quotes from people who responded to the survey

"Feel like we have been used. Making the company so much money in the past, when difficult time come[s] they try and drop our wages 20 percent and change terms and conditions."

currently employed by an airline



"Aviation is at my heart but the pandemic has made me think about securing alternate options as I think every few years with climate change, aviation will continue to impact negatively."

Engineer at an aerospace services company

"Being employed within the aviation sector can have... impacts such as applying for a mortgage because often contracts within aviation can be seasonal... So although the job can be very very rewarding, you are disposable in such a dynamic industry."

former cabin crew member who left due to Covid-related reasons





"The industry has been mismanaged for many years, sacrificing long term security for profit and shareholder dividends. As a result, it is completely ill equipped to deal with outliers like Covid. Too many skilled professionals have been forced from their jobs and the industry has been stripped of skills and experience which will adversely impact safety. Too many years of cost cutting has ruined the airline and aviation industry."

former flight crew member who left due to Covid related reasons

8. Modal shifts: trains



The reduction in greenhouse gas emissions from a modal shift from plane to train travel would be dramatic: taking a plane produces around ten times more greenhouse gases than the same journey by train,³⁸ with potential for further decreases as diesel trains are phased out and electricity grids move towards being fully powered by renewable energy.³⁹ We therefore model a significant movement from plane to rail journeys in our two more ambitious scenarios.

Modelling of High Speed 2 has estimated that it could free up an 576,000 additional daily journeys across the rest of the UK's rail network. This rises to 608,000 if spurs to the HS2 mainline, proposed by Midlands Connect, are developed.⁴⁰ This would provide more than the projected 48m additional annual domestic rail journeys from the most ambitious modal shift we model away from plane travel. A need would still remain to significantly expand capacity throughout the rest of the rail network to match existing patterns of domestic flights. Construction of HS2 is expected to employ 25,000 people, with 3,000 additional jobs created for its permanent operation.⁴¹

Building and maintaining this additional capacity across the network would itself create significant new employment. At current levels of rail productivity, the existing network sustains about 137 jobs for each million passengers carried, based on 2019 figures from the Department for Transport showing 240,000 employees transporting 1,753m passengers over 2018-19.⁴²

³⁸https://drive.google.com/file/d/0B3iR8zs1dVogb3I4MDVZckNRQ1M0aEl1cjRjaVpGS2NUV3Zv/view?resourcekey=0-aNZy3S3_IRxpzbmS4j7EhA

³⁹ Blijenberg, A. (July 2020), *Air2Rail: reducing CO2 from inter-European aviation by a modal shift from air to rail*, Koios Consulting: Delft, p.3

⁴⁰ Midlands Connect (26 September 2019), "Benefits of HS2 revealed for the first time". At: <https://www.midlandsconnect.uk/news/hs2-released-capacity-research/>

⁴¹ *New Civil Engineer* (September 2015), "HS2 construction 'will create 25,000 jobs'". At: <https://www.newcivilengineer.com/archive/hs2-construction-will-create-25000-jobs-17-09-2015/>

⁴² Williams Rail Review (2019), *Williams Rail Review in Numbers*, London: Department for Transport, p.24. At: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/787082/rail-sector-in-numbers.pdf

Modelling the reopening of previously closed stations and operating some new, high-priority schemes to expand capacity, undertaken in early 2019, suggests that the capacity for 20m additional passenger journeys a year can be added, creating 6,500 new jobs – 1,650 directly in rail, up to 3,000 in the rail supply chain, and up to 2,000 in construction and engineering.⁴³ This additional capacity, based on a package of pre-existing but (as as of autumn 2021) unconfirmed schemes, would help build in the flexibility needed to allow the modelled modal shift from flying, at an estimated cost of £4.76–6.39bn.⁴⁴

In addition to transfer of some domestic flights to train journeys, a significant proportion of short-haul plane services within Europe could be expected to transfer to train travel. Britain's only direct international rail link is the Channel Tunnel, from Dover to Calais. Switching services from flights onto tunnel rail services would significantly increase passenger demand for the Channel Tunnel. Passenger movements between France and the UK via air peaked at 12.7m in 2019,⁴⁵ compared to 21.6m Channel Tunnel passenger journeys.⁴⁶ 13.34m passenger journeys were completed by short sea ferry in 2019.⁴⁷ Although it is likely that the business travel component of existing Eurostar demand will remain permanently depressed, moving this large volume of passenger flights onto cross-channel rail links would impose fresh demands on capacity. However, with the Channel Tunnel operating (as of 2019) at around half of its designed capacity, a House of Lords enquiry found "a great deal of spare capacity available in the Channel Tunnel in which further international passenger and freight services could easily be accommodated."⁴⁸

⁴³ Campaign for Better Transport (January 2019), *The Case for Expanding the Rail Network*, London: CBT.

⁴⁴ Campaign for Better Transport (January 2019), *The Case for Expanding the Rail Network*, London: CBT.

⁴⁵ STATISTA:

<https://www.statista.com/statistics/316619/air-travel-between-the-uk-and-france/>

⁴⁶ STATISTA:

<https://www.statista.com/statistics/304968/number-of-passengers-travelling-on-the-eurostar-and-le-shuttle-in-the-united-kingdom/>

⁴⁷ Department for Transport (11 August 2021), "Sea Passenger Statistics", Table SPAS0108. At:

<https://www.gov.uk/government/statistical-data-sets/sea-passenger-statistics-spas#all-uk-international-short-sea-long-sea-and-cruise-passengers>

⁴⁸ House of Lords European Union Committee (29 November 2011), "Tunnel vision? Completing the European rail market", 24th report of the Committee, para.75. At:

<https://publications.parliament.uk/pa/ld201012/ldselect/ldaucom/229/22907.htm#a35>

We assume here that the required wider European capacity for rail passengers is available, given the EU's own plans to significantly expand services over the next two decades, doubling high-speed capacity by 2030.⁴⁹ The emissions reductions on the outbound leg of an international train journey from the UK count towards the UK's carbon budget, since a domestic take-off is removed and replaced with train transport.

Passenger numbers on domestic UK railways have expanded in the last decade or more, rising from 1.351m passenger journeys in 2010-11 to 1.753m in 2018-19 – an increase of almost 30%. Figures for total railway employment are harder to obtain but, treating Train Operating Company (TOC) employment as a proxy, jobs have risen in parallel, from 49,450 in 2009 to 61,230, an increase of 24%. The implication is that (at least in per-worker terms) productivity has only improved relatively slightly on the railways, with additional passenger travel requiring additional employment at close to the same pace of growth. This is in line with the Office for the Rail Regulator's own findings of comparatively limited labour efficiency gains on railways.⁵⁰

Assuming, on this basis, that the number of jobs required per rail passenger will remain broadly stable over the next decade allows us to estimate the following additional employment from the expansion in rail passenger numbers under a modal shift away from flying:

⁴⁹ International Rail Journal (7 June 2021), "Breaking down Europe's ambitious plans for rail". At: https://www.railjournal.com/in_depth/pie-in-the-sky-or-realistic-and-deliverable-breaking-down-europes-ambitious-targets-for-rail

⁵⁰ Office for the Rail Regulator (2012), *Scope for improvements in the efficiency of Network Rail's expenditure on support and operations*, London: ORR

Table 2. Additional rail employment in 2030 under a modal shift away from plane travel.

	Additional passenger journeys (millions)	Additional direct jobs
Baseline scenario	0	0
Fairer Flying scenario (50% reduction in flights)	75.7	10,449
Safer Climate scenario (67% reduction in flights)	99.79	13,774

These figures are in line with the expansion in railway employment over the last decade. We would expect the structure of these jobs to be very close to existing employment on the railways, with 67.8% in labour-intensive and essential maintenance operations, furthest removed from most employment in aviation, but most of the remainder (4,270 jobs in the Safer Climate scenario) open to easier access from aviation via support for retraining.

The rail employment multiplier for the UK, accounting for the supply chain impacts, has been estimated as 2.3, meaning that each additional person employed within the industry itself will create (on average) a further 2.3 jobs in the wider economy through the additional demand for inputs needed to support them. This implies a direct impact from expanding rail employment of 10,500 jobs in the Fairer Flying scenario (50% reduction in flights), and nearly 14,000 direct jobs in the Safer Climate scenario (67% reduction in flights). Because these additional jobs are further down the supply chain, incorporating (for example) the manufacture and repair of trains, they are less likely to be direct substitutes for existing aviation employment; but at least some aviation supply chain employment, otherwise affected by the industry's contraction, could transfer over.

Retraining from aviation to rail

Many aviation jobs would be transferable to low-carbon modes of transport without the need for retraining, such as workers transitioning from jobs in airport retail to rail station retail. For those where retraining would be required, examples exist of schemes to support this transfer. Aeropers, the union representing pilots in Switzerland, has proposed a retraining scheme for its members to move more rapidly into train driving.⁵¹ A number of former pilots are already making the move, backed by support from both Swiss carriers and their trade union. As in Switzerland, British rail companies have reported persistent driver shortages over the last five years. Train cancellations due to staff shortages have risen fivefold between 2014 and 2019, with 35,000 services pulled that year for a lack of staff, typically (but not always) a lack of drivers.⁵² This pre-Covid problem has been exacerbated since the Covid crisis by requirements to self-isolate.⁵³ If a significant expansion of rail employment is anticipated these roles could be suitable alternatives for people previously employed in aviation, particularly if support were to be provided for the costs of retraining (up to 18 months as a driver) over the transition.

Earlier proposals from NEF on adapting to the immediate pandemic shock to aviation, including the transformation of the Coronavirus job support scheme into a retraining package, would result in substantial savings to the taxpayer as a result of reduced payments for unemployment benefits.⁵⁴ A “right to retrain” for aviation, in the light of the urgent need for the sector to reduce its emissions, would produce net savings for society as a whole, as well as generate significant social benefits by supporting workers in high-carbon sectors who wish to move into expanding lower-carbon sectors to do so as seamlessly as possible.

⁵¹ Coffey, H. (24 November 2020), “Swiss pilots could retrain as train drivers”, *Independent*. At: <https://www.independent.co.uk/travel/news-and-advice/pilots-swiss-train-drivers-railway-b1760919.html>

⁵² Paton, G. (4 February 2019), “Rail crew shortages led to 35,000 train cancellations”, *Times*. At: <https://www.thetimes.co.uk/article/rail-crew-shortages-lead-to-35-000-train-cancellations-bwk05lmp2>

⁵³ BBC News (23 July 2021), “Rail services face cuts as staff self-isolate”. At: <https://www.bbc.co.uk/news/business-57940660>

⁵⁴ Chapman, A. and Wheatly, H. (June 2020), *Crisis Support to Aviation and the Right to Retrain*, London: New Economics Foundation. At: <https://neweconomics.org/uploads/files/aviation-workers.pdf>

9. Modal shift: ferries



Some UK domestic flights – those being made to Northern Ireland and outlying islands – are across the sea and therefore cannot be replaced directly by existing rail infrastructure. This implies that at least some of these flights will need to be replaced by ferry services. A proportion of flights currently being taken abroad can also be replaced by ferry alternatives. We modelled this impact, using the current jobs density of ferry passenger transport, to show that shifting to ferry use in the Fairer Flying scenario could create 3,000 new jobs, or 3,900 in the higher ambition Safer Climate scenario. Technology exists to decarbonise passenger ferries and provide a clean power source, including electric power, wind ships⁵⁵ and ships powered by a combination of wind and electricity. This could provide a decarbonised alternative to flights such as those between Great Britain and Northern Ireland or the Republic of Ireland. Shorter journeys, such as those providing mainland connectivity to remote islands, would be an ideal market-entry point for emerging technologies such as electric planes, which are suited to small distances and low numbers of passengers. The UK is ideally placed to lead on this frontier.

⁵⁵ <https://wind-ship.org/en/grid-homepage/>

10. Expanding domestic tourism



In 2018, the UK's domestic tourism industry contributed £127.5bn to UK GDP, or about 6.7% of the whole economy, and employed 3.9m people in industries connected to tourism.⁵⁶ The sector has been impacted by the pandemic, with visitors to the UK falling 96% in the second quarter of 2020 compared to 2019.⁵⁷ However, early evidence from the Centre for Cities shows that prime locations for domestic tourism, such as Blackpool and Bournemouth, have seen sharp declines in their usage of furlough, suggesting a solid recovery driven by domestic tourism, albeit from a weaker base.⁵⁸

Forecasts by Oxford Economics are significantly brighter for domestic tourism than international, suggesting that (without government intervention) "domestic day visit spend is forecast to recover its pre-pandemic baseline by the close of 2021, whilst domestic overnight spend will recover to 87% of 2019 levels during this time."⁵⁹ The Department for Digital, Culture, Media and Sport's Tourism Recovery Plan aims to improve the overall prospects for the industry, bringing forward the expected recovery to 2019 levels of visitors and spending (from both domestic and international sources) from 2025 to no later than the end of 2023.⁶⁰

We assume a significant shift away from international travel and towards domestic tourism, driven by the coronavirus pandemic (in the immediate future), and then by shifting consumer preferences and policy decisions as ambition amps up on emissions reductions, along with growing public concern about the climate crisis and consumer willingness to change behaviour to reduce emissions. In contrast to

⁵⁶ ONS (15 February 2021), "Coronavirus and the impact on the UK travel and tourism industry". At: <https://www.ons.gov.uk/businessindustryandtrade/tourismindustry/articles/coronavirusandtheimpactontheuktravelandtourismindustry/2021-02-15>

⁵⁷ Ibid.

⁵⁸ Rodrigues, G. (29 July 2021), "What do the latest furlough statistics tell us about labour markets in the UK's largest cities and towns?", Centre for Cities blog. At: <https://www.centreforcities.org/blog/the-latest-furlough-statistics/>

⁵⁹ Department for Culture, Media and Sport (June 2021), *Tourism Recovery Plan*, London: DCMS, p.16. At: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/992974/Tourism_Recovery_Plan_Web_Accessible_.pdf#page=15

⁶⁰ DCMS (11 June 2021), *The Tourism Recovery Plan*, London: Department for Digital, Culture, Media and Sport. At: <https://www.gov.uk/government/publications/tourism-recovery-plan>

aviation, a capital-intensive sector, tourism is strongly labour intensive: while some capital substitution has taken place in recent years – for example, in online booking substituting for travel agents – the basis of providing tourism services is likely to remain labour intensive. Automation is harder than in other service industries: the tasks are heterogeneous, varying greatly even within the same sub-sector, and many require “emotional intelligence and empathy” that are either very difficult or potentially impossible to automate.⁶¹

Government analysis finds that tourism employment (as full-time equivalent jobs) grew from 1.28m in 2013 to 1.43m in 2019⁶² – a faster rate of growth than visitor numbers overall, in stark contrast to aviation’s declining job intensity and demonstrating the labour-intensive nature of the tourism industry.

Assuming no significant labour-substituting technological changes occur in UK domestic tourism over the next decade, in line with industry expectations, we hold the jobs density of tourism per visitor constant. This implies a total job creation of 293,700 in the Fairer Flying scenario and 391,700 in the Safer Climate scenario – a growth in the sector’s employment of 17% and 23% respectively, to give an indication of the scale of the change to 2030.

This is a significant expansion, but not excessive compared to recent growth. Tourism employment in the UK grew by approximately 500,000 in the decade between 2010 and 2020, well ahead of government expectations at the time.⁶³ The implied growth in the modelling here is between 60 to 80% of the previous decade’s growth. The government has recently identified significant skills gaps within the existing UK tourism sector, alongside substantial skills-based vacancies. Funding could be provided by government for the training and retraining needed to sustain expansion of domestic tourism, particularly in the context of declining employment in the aviation industry.

⁶¹ Ivanov, S. (June 2020). “The impact of automation on tourism and hospitality jobs”, *Information Technology & Tourism* 22

⁶² ONS (21 April 2020), “Provisional estimates of direct tourism employment for 2018 to 2019”, Table 2. At: <https://www.ons.gov.uk/businessindustryandtrade/tourismindustry/adhocs/11609provisionalestimatesofdirecttourismemploymentfor2018to2019>

⁶³ Forecasts cited by government anticipated 280,000 additional tourism jobs by 2020. UK Commission for Employment and Skills (August 2012), *Sector Skills Insight: Tourism*, Evidence Report 55, London: HMSO, Table 2.2. At: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/304260/Sector_Skills_Insights_Tourism_evidence_report_55.pdf

A significant proportion of jobs currently undertaken in the air travel sector can transfer rapidly into domestic tourism, notably those involving direct customer relations. However, parts of the tourism sector itself remain significantly un-unionized, and pay and conditions would need protection, alongside retraining where required.

11. Efficiency increases



Annual fuel efficiency improvements in the aviation industry have been relatively modest, not exceeding 2% a year, and the more rapid increase in passenger demand led to a sustained net increase in emissions. Breaking this pattern will require more than the remaining incremental improvements in jet technology. Moreover, an improvement in efficiency alone does not guarantee a reduction in emissions: the “Jevons paradox” shows that as the cost of a pollutant falls, more of it is demanded, resulting in the same or even more pollution being produced. Improvements in efficiency, if translated simply into cost reductions by competitive and profit-maximising airlines, are likely to lead to higher overall emissions. The pattern of the last few decades of jet engine use fits this pattern. Policy and business model change will be needed if future efficiency improvements are to actually reduce emissions. In addition, the efficiency improvements likely to appear with existing technologies are simply not large enough to meet more ambitious carbon reduction targets.

We have considered the potential for modal changes in transport, shifting passengers out of air travel and into low-emission alternatives. We will now consider the possibility of technological changes within the aviation sector which would have job-creation potential. The aviation sector is hoping that various technologies will emerge to allow decarbonised flight: alternative methods of propulsion, and alternative fuels that can be used to power existing planes.

12. Alternative planes and alternative fuels



Both the UK aviation industry and the UK government are keen for the availability of decarbonised flights to avoid the need for demand management. However, the evidence suggests that relying on technological developments to allow unconstrained aviation growth will not work, due to the intrinsic physical difficulties of developing new types of aircraft.⁶⁴ The aviation industry itself acknowledges that electric planes won't be widely commercially available even for shorter range flights until 2040 and won't be able to make journeys longer than 400km, making multiple legs required for longer journeys.⁶⁵ Hydrogen-powered planes are not likely to enter into service until 2035 at best.⁶⁶ The much greater weight of batteries and volume of hydrogen compared to kerosene make it particularly difficult to develop planes able to cover longer distances or carry large numbers of passengers.

Problems with alternative fuels, often called "sustainable aviation fuels" (SAF), include a very limited supply and high costs, as well as questions over whether they can actually generate system-level emissions reductions compared to kerosene. Due to the deforestation issues with biofuels and the high fossil plastic content in fuels from waste, we do not believe that either can provide genuine emissions reductions when produced at scale and so they are not included in this modelling.

⁶⁴<https://s3-eu-west-1.amazonaws.com/media.afreeride.org/documents/Electric+Dreams.pdf>

⁶⁵www.sustainableaviation.co.uk/wp-content/uploads/2020/02/SustainableAviation_CarbonReport_20200203.pdf

⁶⁶<https://physicstoday.scitation.org/doi/10.1063/PT.3.4632>
<https://archives.greenairnews.com/www.greenaironline.com/news4a70.html?viewStory=2717>

Alternative aviation fuels: What are they and how do they impact emissions?

There are three main feedstocks for creating alternative jet fuels: biomass, waste or carbon dioxide itself. Each has different potential to reduce warming created by flying.

- Biofuels can be created from crops or agricultural residues. Given the scale of aviation's fuel demand, land would not be available to produce crops for biofuels in sufficient quantities to power aviation without causing hugely damaging biodiversity loss along with deforestation, which increases total emissions.⁶⁷ Growing crops for fuel, rather than for food, also poses risks to land rights and food security in developing countries. Analysis on the biomass that would be needed to replace current kerosene demand with biojet finds that this would require an additional harvest of double the current production of biomass for food.⁶⁸
- Fuels can also be produced from waste, such as municipal solid waste. However, in addition to containing biological material, this also contains a high proportion of plastic waste, which is derived from fossil fuels. Fuels from waste produce more emissions than conventional kerosene, and can only be made to look like a low-emissions option by creative accounting which includes avoided emissions from landfill.⁶⁹ More sustainable biomass waste sources such as used cooking oil provide far too small a source to be scaled to anything more than a tiny proportion of existing jet fuel consumption.

⁶⁷<https://sdg.iisd.org/news/rainforest-norway-report-finds-aviation-emissions-reduction-targets-could-drive-deforestation/>

⁶⁸ <https://ukfires.org/blog-cop26/>

⁶⁹ www.pnas.org/content/pnas/suppl/2021/03/10/2023008118.DCSupplemental/pnas.2023008118.sapp.pdf#page=24

- E-fuels are created by using electricity to synthesise fuels from carbon and hydrogen. The carbon can be either captured directly from the air, or from a point source such as the chimney of a power station or exhaust of a steel manufacturing facility. The hydrogen can be “grey”, “blue” or “green”, depending on whether it’s produced from fossil fuels or fossil fuels with carbon capture, or by electrolysing water. To optimise the emissions reductions from e-fuels, they must be created using renewable electricity, carbon captured from the air and green hydrogen.⁷⁰

The aviation industry and the UK government rely on alternative fuels as a crucial part of a path to future operations in a net-zero world. However, e-fuels are currently only at the stage of proof of concept, and will remain expensive due to their intrinsically high energy requirements. In addition, while e-fuels may indeed manage to achieve carbon neutrality, only a third of the warming produced by burning fuel in planes derives from emissions of carbon dioxide, with other greenhouse gases including water vapour and nitrous oxides accounting for two thirds of aviation’s warming. It is currently unclear to what extent e-fuels will be able to reduce aviation’s non-CO2 impacts, with estimates of climate impact reduction potential of between 30% and 60% per passenger km.⁷¹

The energy requirements should also be taken seriously by those of us proposing e-fuels as a route to aviation decarbonisation. Our modelling suggests that, to provide sufficient fuel to accommodate a quarter of 2019 aviation fuel demand, e-fuels would require energy inputs of around the same size as the UK’s 2021 total installed renewable generating capacity. However, both the aviation industry and the UK government support alternative fuels and anticipate their playing a key role in aviation in a climate-safe future. If their optimism is to be realised, policies would be needed to facilitate the speed and scale of the increase in renewable energy that will be required, such as a high tax on kerosene emissions combined with lower passenger taxes on planes running on e-fuels, along with a strategy to ramp up

⁷⁰www.transportenvironment.org/discover/electrofuels-yes-we-can-if-were-efficient/

⁷¹www.fch.europa.eu/sites/default/files/FCH%20Docs/20200507_Hydrogen%20Powered%20Aviation%20report_FINAL%20web%20%28ID%208706035%29.pdf

renewable energy at the scale required. None of these policies are in place, although the Department for Transport's modelling optimistically assumes the possibility of a "breakthrough" in alternative fuels.⁷² **Even under extremely optimistic assumptions about e-fuels development and cost reductions, a significant reduction in aviation demand cannot be avoided if the UK is to comply with its climate commitments.**

However, we have made generous assumptions about e-fuel availability in 2030 both because they are the best potential short-term solution to allow some level of aviation to continue while minimising harm to the climate; and because the aviation industry and the government expect them to play a role. The onus is therefore on the industry to bring them to market. Our modelling assumptions about the availability of e-fuels are much more optimistic than those made by the Climate Change Committee, which assumes (correctly, based on the industry's current plans) that e-fuels will not be in play by 2030.

The industry's sustainability body suggests only a small role for alternative fuels by 2030, and does not foresee e-fuels entering the mix until later than that, instead using more polluting but cheaper and easier to produce alternatives such as fuels from waste and biomass, rather than e-fuels.⁷³ It could be possible though that, under the much more stringent emissions reductions required for aviation in our scenarios, there would be greater incentives to develop e-fuels and bring them to market earlier. As e-fuels currently pose the most effective and fastest to develop option to reduce the harm caused to the climate by flying, we argue that the industry should put greater resources into their development and aim to start using them more rapidly.

We have not included offsets or carbon capture and storage in our modelling because they do not offer the in-sector emissions reductions which aviation urgently needs. The Climate Change Committee has advised the government that offsets should only be based on "verifiable emissions removal from the atmosphere" and cannot "be a substitute

⁷²https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1002154/jet-zero-consultation-a-consultation-on-our-strategy-for-net-zero-aviation.pdf

⁷³www.sustainableaviation.co.uk/wp-content/uploads/2020/02/SustainableAviation_CarbonReport_20200203.pdf

for genuine emissions reductions”.⁷⁴ This would not allow the offsetting schemes being used by airlines today, which involve development projects, investment (often not additional⁷⁵) in clean energy projects, or forest protection schemes (which also fail to provide additional benefits⁷⁶).

⁷⁴www.theccc.org.uk/publication/letter-international-aviation-and-shipping/

⁷⁵www.cesifo.org/en/publikationen/2021/working-paper/do-carbon-offsets-offset-carbon

⁷⁶www.theguardian.com/environment/2021/may/04/carbon-offsets-used-by-major-airlines-based-on-flawed-system-warn-experts

13. E-fuels production



By using carbon captured from the air rather than the fossil carbon of current jet fuel, synthetic fuels can (in theory) achieve carbon neutrality, although not climate neutrality due to the difficulty of eliminating non-CO₂ emissions.⁷⁷ The first regular flight using some e-fuel in the fuel mix, a KLM commercial flight from Amsterdam to Madrid, took place in 2021. Airbus reported that 5% of the Boeing 737's total fuel, some 500 litres, was derived from this source, although the source of the carbon used was an oil refinery rather than air capture.⁷⁸

This technology is presently a long way from commercial viability but could potentially play a key role in reducing aviation emissions if significant resources were put into its research and development. At present, the cost of e-fuel is much higher than that of kerosene, and the capacity to produce anything like the scale required by the industry is not in place by many orders of magnitude.

In our Safer Climate scenario, we assume that the entirety of fuel demand for flights has been replaced by e-fuels by 2030.⁷⁹ The Fairer Flying scenario assumes a 50% switch by the same date, reflecting the likelihood that supplies of e-fuel will be extremely limited and able to fulfil at best only a small fraction of pre-Covid aviation demand. Both of these scenarios model the use of e-fuels to fulfill a quarter of 2019 aviation fuel demand in 2030.

The UK government is consulting on a proposed two-stage deadline for the use of alternative fuels in aviation, setting a target of 10% use by 2030 and 75% use by 2050, although in the different context of unconstrained demand. The lower the total levels of aviation and demand for jet fuel, the higher the proportion of demand which will be able to be met by e-fuel.

⁷⁷ International Civil Aviation Organization (10 September 2019), "Power-to-Liquids (PTL): sustainable fuels for aviation", Working Paper A40-W526. At: https://www.icao.int/Meetings/a40/Documents/WP/wp_526_en.pdf

⁷⁸ Proper, E. (8 February 2021), "KLM makes regular flight with sustainable synthetic fuel", *Bloomberg*. At: <https://www.bloomberg.com/news/articles/2021-02-08/klm-makes-first-regular-flight-with-sustainable-synthetic-fuel>

⁷⁹ This follows the assumptions made by Centre for Alternative Technology (2019), *Zero Carbon Britain: rising to the challenge*, Macynlleth: Centre for Alternative Technologies.

To meet the challenge of accelerated adoption, a step-change in research and production intensity within the sector would be required, along with financial incentives to make burning kerosene much more expensive.

14. Changes within aviation



To model the impact of an accelerated switch into e-fuels, we have simulated a simple adoption curve, showing an initially slow pace of adoption and expanded use that accelerates towards the end of our modelling period.⁸⁰ This determines the pace of the two separate employment impacts:

1. Employment in the renewables sector, outside of aviation, as the construction and operation of new renewable energy projects accelerates to meet increased demand.
2. Employment inside aviation, as new infrastructure, repair, supply, training and other jobs are created with the introduction of a new technology, and with an increased focus on emissions reductions.

Incorporating these impacts substantially reduces the within-industry effects of a reduction in passenger numbers, and very significantly expands potential job creation in the energy sector and e-fuel production.

⁸⁰ This is a standard assumption in the innovation literature, dating back to Everett Rogers first proposing an “S-curve” shape for innovation use in 1963. See Rogers, E. (2003), *Diffusion of Innovations*, 5th Edition, New York: Simon and Schuster.

15. Employment within aviation



The implication of more rapid and ambitious targets for cutting aviation emissions is not only that demand is reduced, but that within the aviation industry there is much greater focus on minimising emissions to the extent possible, which also offers potential for job creation. At present, the primary divide within the sector is between long- and short-haul aircraft: we have modelled a major reduction in both, with many trips currently by air replaced by alternative modes of transport. We now also look at impacts of attempts to reduce the emissions of remaining flights, which also offers potential for job creation.

The refitting and retooling of existing aviation infrastructure to support emissions reduction goals will require investment by the industry and the creation of jobs in the operation and management of new infrastructure, even as passenger numbers overall decrease. This would represent a historic break in the trend of decreasing aviation jobs per passenger.

Reducing the speed at which aircraft fly has potential to reduce their emissions. Research into domestic US flights suggests a reduction in fuel burn of 3.5% is possible where airspeeds are optimised for emissions reduction.⁸¹ Aircraft currently fly about 8% faster than their optimum speed: the relative waste of fuel is worth it for airlines to reduce turnaround costs and maximise passenger-miles.⁸² We suggest that this calculation would change in a world with tighter emissions constraints, more expensive fuel and greater penalties attached to emissions. Most benefit would come from the fresh design of a medium-range aircraft optimised around a lower design cruise speed – again, requiring engineering R&D jobs.

We therefore expect an increase in the length of time per mile flown. For passengers, flights would become less frequent, somewhat more leisurely, and more often taken only for

⁸¹ Lovegren, J.A., and Hansman, R.J. (February 2011), “Estimation of potential aircraft fuel burn reduction in cruise via speed and altitude optimisation strategies”, Report No. ICAT-2011-03, MIT International Centre for Air Transportation: Cambridge, MA. At: <https://core.ac.uk/download/pdf/4426749.pdf>

⁸² Kemp, J. (26 September 2014), “Airlines fly slower to cut fuel bill”, *Bloomberg*. At: <https://www.reuters.com/article/airlines-fuelcells-kemp-idUSL6N0RR2ZO20140926>

relatively longer journeys for which other transport options are not available, and for which alternative, closer destinations were not viable, such as visits to family in distant countries. Demand for airport services per flight is likely to increase, and longer journey times imply more demand for in-flight services. Alongside the retooling, refitting, and retraining needed for technological changes, this change in the experience of flying is likely to increase demand for service employment. Airports themselves will need redesigning and refitting to install the infrastructure needed for new fuels, provisions for slower flights or for flights to be split into multiple legs to improve efficiency, along with better integration into other public transport modes.

If we see flying as one part of an integrated transport system, encompassing different modes of travel and prioritising low-emissions surface travel wherever possible, further scope for employment creation is opened up in the management of modal shifts and the provision of services for passengers switching between different forms of transport. Again, it is the composition of demand from passengers – rather than the absolute volume of journeys, which remains the same across the three scenarios – which has potential to create new jobs. By shifting technologies being used from relatively more capital-intensive to relatively more labour-intensive ones, more jobs can be created even at lower levels of aviation demand, while maintaining overall mobility for passengers with a modal shift to lower emissions forms of transport and shorter journeys.

The New Economics Foundation has previously proposed a retraining fund, paid from the new National Skills Fund, that would guarantee retraining for people in the aviation sector. Using their estimated costs for a three-year programme for each employee requiring support during retraining, the total, decade-long costs for an aviation retraining scheme are £800m in the baseline scenario; £1.2bn for the Fairer Flying Scenario; and £1.6bn in the Safer Climate scenario. Given that the taxpayer handout to the sector pre-Covid in the form of exemptions from VAT and fuel duty amounted to £7bn per year, this does not seem an unreasonable amount to expect the industry to contribute via taxation to support workers.⁸³

⁸³ This is based on an average cost per retrained employee of £8,600 for three years retraining. Calculated from Chapman, A. and Wheatly, H. (June 2020), "Crisis support to aviation and the right to retrain", New Economics Foundation, Table 1. At: <https://neweconomics.org/uploads/files/aviation-workers.pdf>

16. Renewable electricity demand and job creation



A shift towards e-fuels creates very substantial additional demand for electricity. The *Zero Carbon Britain* decarbonisation scenario, which we follow for the Safer Climate scenario, suggests that 40 TWh of synthetic liquid fuels would be required each year for aviation.⁸⁴ The job creation capacity of e-fuels per unit is significantly higher than conventional oil-based fuel. This is due to the greater demand for labour in the expansion of renewable capacity to meet the increased demand. Jobs would also be created by the processes needed to synthesise fuels from carbon and hydrogen, as well as those needed to create green hydrogen. For the UK, a switch into e-fuels could also create potential for domestic generation and production of fuel. E-fuel or green hydrogen production could be a good use of electricity generated by remote North Sea offshore wind which is more difficult or expensive to connect to the grid, potentially providing green jobs that would be available for people working regionally in oil and gas who want to move out of the fossil fuel sector.

Current UK employment in the primary component of the UK conventional fuel supply chain (listed by the ONS as “oil and gas extraction” and “extraction support”) amounts to 57,000. The UK Oil and Gas Operators’ Association estimates a total of 151,000 are employed throughout the entire supply chain.⁸⁵ However, the UK is one of the largest importers of jet fuel in the OECD. Just over 40% of UK demand for jet fuel is met by production in the UK, with the rest of the around 12bn litres being imported.⁸⁶ Changes in demand for primary fuels in the aviation industry will therefore have a more limited negative impact on UK employment. In addition, the industry itself is

⁸⁴<https://cat.org.uk/info-resources/zero-carbon-britain/research-reports/zero-carbon-britain-rising-to-the-climate-emergency/>

⁸⁵ House of Commons Exiting the European Union Committee (2017), “Oil and Fossil Fuel Production (including Gas) Sector Report”, p.4. At: <https://www.parliament.uk/globalassets/documents/commons-committees/Exiting-the-European-Union/17-19/Sectoral-Analyses/25-Oil-and-Fossil-Fuel-Production-Report.pdf>

⁸⁶ BEIS (2019), *Digest of United Kingdom Energy Statistics 2019*, London: Department for Business, Energy and Industrial Strategy, p.46. At: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/840015/DUKES_2019_MASTER_COPY.pdf

highly capital intensive, meaning that changes in demand for its products have a more limited employment impact. But assuming a straight pass-through from falling demand to long-term employment, we might expect an equivalent long-run reduction in employment of 11,200 throughout the fuel supply chain as the substitution occurs.

These reductions in employment would be more than compensated for by the construction and operation of the new renewable capacity required for efuels. Using existing modelling on construction and maintenance employment creation per megawatt of installed renewables capacity,⁸⁷ and plausible assumptions about the efficiency of e-fuel production by 2030, we estimate that in both the Fairer Flying and Safer Climate scenarios a further 38 GW (gigawatts) of renewable capacity will be needed. Assuming current efficiency of generation for wind and labour requirements for installation, this would create around 47,000 jobs from increased electricity requirements alone as e-fuels production is ramped up.

For comparison, at the end of August 2021, the UK had 10,973 wind turbines with a total installed capacity of 24.2 gigawatts,⁸⁸ making it the sixth largest wind energy producer in the world. The expansion required for e-fuels is therefore significant, reflecting the high energy needs involved. Nonetheless, a serious attempt to decarbonise aviation would necessitate this expansion, and the sheer size of the increased capacity needed would have a positive impact on job creation.

⁸⁷ Cambridge Econometrics, *Future UK Employment in the Offshore Wind Industry* (June 2017). Available at: <https://aura-innovation.co.uk/wp-content/uploads/2020/04/Cambridge-Econometrics-Future-UK-Employment-in-Offshore-Wind-June-2017.pdf>

⁸⁸ UK Wind Energy Database (UKWED), accessed 22 August 2021. At: <https://www.renewableuk.com/page/UKWEDhome>

17. Step-change in research and development (R&D) within aviation



We expect that, under tighter emissions constraints, there would be an increase in industry efforts to achieve lower emissions forms of flight, and to reduce aviation emissions to the extent possible using available technologies. Substantial research would need to be applied to allow new technologies to reach commercial use. The need for both additional research effort and to overhaul existing infrastructure has substantial job creation potential.

The UK aviation industry is presently on the lower end of G7 research expenditure, spending equivalent to 16% of aerospace industry value added in 2017, compared to 21% in France and the US and 30% in Italy. UK aviation industry R&D spending, at £1.69bn in 2019, remains below its 2007 peak of £2.89bn (in 2019 real terms).⁸⁹

This suggests significant room for additional R&D spending by UK-based aerospace companies, with the potential to create many thousands of new, skilled jobs. Assuming the job efficiency of current research spending continues,⁹⁰ an increase in R&D spending to 2007 levels would create an additional 10,890 jobs. This is a reasonable baseline commitment for the industry to achieve, but would represent only a return to pre-financial crisis levels of investment. The need to reduce emissions – and an ambition to achieve rapid commercialisation of low-carbon technologies – requires a major increase in R&D spend to have any chance of bringing new technologies into usage on the timeframes required.

Expanding production of e-fuels would require a major reduction in the cost of production, and a corresponding expansion in output. The required economies of scale cannot be achieved with existing production technology, and will

⁸⁹ OECD (2021), Main Science and Technology Indicators. At: <https://www.oecd.org/sti/msti.htm>; OECD (2021), Value Added by Activity. At: <https://data.oecd.org/natincome/value-added-by-activity.htm>

⁹⁰ In 2019, the 15,000 researchers employed in the ONS “Aerospace” product group were supported by £1.679bn of R&D spending within aerospace, or £111,934 per job. Figures taken from ONS (20 November 2020), “Business enterprise research and development”, Table 13. At: <https://www.ons.gov.uk/economy/governmentpublicsectorandtaxes/researchanddevelopmentexpenditure/datasets/ukbusinessenterpriseresearchanddevelopment>

require further technological breakthroughs. That, in turn, necessitates a major step-change in the industry's expenditure on R&D: there are no guarantees that the breakthroughs hoped for by the industry can be achieved, but additional resourcing for R&D at least brings them somewhat closer to plausibility.

It is difficult to judge the appropriate scale of this commitment, given the uncertain outcomes from frontier research. Nonetheless, assessments by the European Commission in 2017 point to the potential impact of rapid increases in research expenditure in shifting existing e-fuels technologies towards commercial viability.⁹¹

The size of the expansion in research funding required to develop decarbonised flight is subject to substantial uncertainty, but current industry experience can act as a guide. The cost of developing a new jet engine by modifying existing technologies was estimated at around \$1bn (£730m).

⁹² However, the development of new propulsion and fuel technologies will be far closer to the scale of technical advances required to develop and bring a new aircraft to market than to develop a single major component, or to modify existing models. For example, Boeing's 787 Dreamliner project was launched in 2004 and the first aircraft entered service eight years later in 2012. Total development costs were \$13.4bn (£10bn), or an average spend of \$1.675bn (£1.23bn) every year from project launch to the first craft entering service.⁹³

One recent study found that new propulsion systems tended to take longer to reach maturity from any given level of technological readiness, taking around 20 years before the most early-stage technologies were market-ready.⁹⁴ The same study noted the substantial increase in costs for bringing a wholly new aircraft to market, relative to ongoing

⁹¹ European Commission (November 2017), "Research and Innovation perspective of the mid - and long-term Potential for Advanced Biofuels in Europe", Directorate-General for Research and Innovation: Brussels. At: <https://www.biolig.de/downloads/FinalReport-2017-EN.pdf>

⁹² The Economist (24 January 2014), "Gearing up for a fight". At: <https://www.economist.com/business/2014/01/25/gearing-up-for-a-fight>

⁹³ Bowen, J. (2010) The Economic Geography of Air Transportation: Space, Time, and the Freedom of the Sky. London: Routledge. Quoted at "The Development Costs for Selected Aircraft", *The Geography of Transport Systems*, <https://transportgeography.org/contents/chapter5/air-transport/aircraft-development-costs/>

⁹⁴ Nolte, P., Apffelstaedt, A., Gollnick, V. and Rötger, T. (2012) "Quantitative Assessment of Technology Impact on Aviation Fuel Efficiency". Air Transport and Operations Symposium 2012, 18.-20. June 2012, Delft, Figure 16.

redesign, as well as significant inflation in the cost of research over time.⁹⁵

The standard methodology for forecasting future costs of research and development is “Technology Readiness Levels” (TRLs), ranked from 1 to 9, which provide qualitative but standardised means to assess the current prospects of any product currently being researched. For the set of technologies and processes that are needed to produce e-fuels, such as alkaline electrolysis and reverse water gas shifting, one recent survey estimated most relevant technologies were clustered around TRLs 6–9, indicating a proximity to market.⁹⁶

Taking these costs and research forecasts as a guide, the primary barrier to achieving commercially viable low carbon propulsion technologies is the commitment of research resources needed to deliver technologies at a relatively advanced stage of development at scale. For the UK, a step-change in research effort and funding would therefore be needed to achieve commercially-viable alternative fuels inside the time-frame envisaged in this report.

Increasing the UK’s current aerospace research spend to £3.9 bn has the potential to create an additional 68,000 jobs by 2030, based on the industry’s own estimates.⁹⁷ This would need to be heavily concentrated in the development of new propulsion systems and research into low-carbon technologies (primarily including e-fuels), rather than concentrating on more minor adjustments to existing plane technology.

⁹⁵ *ibid.*, p.17

⁹⁶ Soler, A. (2020), *The Role of E-fuels in the European transport system: literature review*, Brussels: Concawe Low Carbon Pathways Joint Group, Table 22

⁹⁷ Aerospace Technology Institute (1 July 2020), “ATI welcomes government R&D roadmap”. At: <https://www.ati.org.uk/news/ati-welcomes-government-rd-roadmap/>

18. Results



The below table shows jobs created and lost relative to aviation employment in 2019. In this project we have not mapped the skills needed to transfer directly from jobs which are being lost to new jobs which are being created, and we do not suggest that this will be possible in every case.

The job losses from reducing passenger numbers do not match wider industry job losses, as even with fewer passengers flying there is still a need for ground staff and other services, which changes gradually over time with further technological change and efficiency improvements.

Table 3: Changes in employment in each sector by 2030 compared to the industry in 2019. All numbers given in thousands.

Sector	Baseline scenario	Fairer Flying scenario (50% reduction in flights)	Safer Climate scenario (67% reduction in flights)
Aviation jobs (lost)	-94.30	-139.3 (-41 in aviation operations, -98 ancillary and ground staff)	-186.7 (-56 in aviation operations, -130 in ancillary and ground staff)
Rail	-	10.4	13.8
Ferry	-	3.0	3.9
Research and development within aviation	-	68.0	68.0
Domestic tourism	-	293.7	391.7
Renewables capacity to create alternative fuels	-	46.8	46.8
Total jobs created	0	421.9	524.1
Total jobs change (jobs created minus jobs lost)	-94.3	282.6	337.5

For every one job lost in aviation, around three are created in the sectors which will need to expand to support climate-friendly travel. The following table shows the number of jobs created in each of the sectors that will need to expand under a modal shift from flying, per job which is lost from aviation.

Table 4: Number of jobs created per job lost in aviation under a modal shift to more climate-friendly ways of travelling.

Sector	Fairer Flying scenario	Safer Climate scenario
Rail and ferry	0.10	0.09
Research and development within aviation	0.49	0.36
Domestic tourism	2.11	2.10
Renewables capacity to create alternative fuels	0.34	0.25
Total	3.03	2.81

The following graphs display the changes in jobs supported in each scenario.

Figure 7: Jobs lost each year in aviation and created in other sectors under the Fairer Flying scenario.

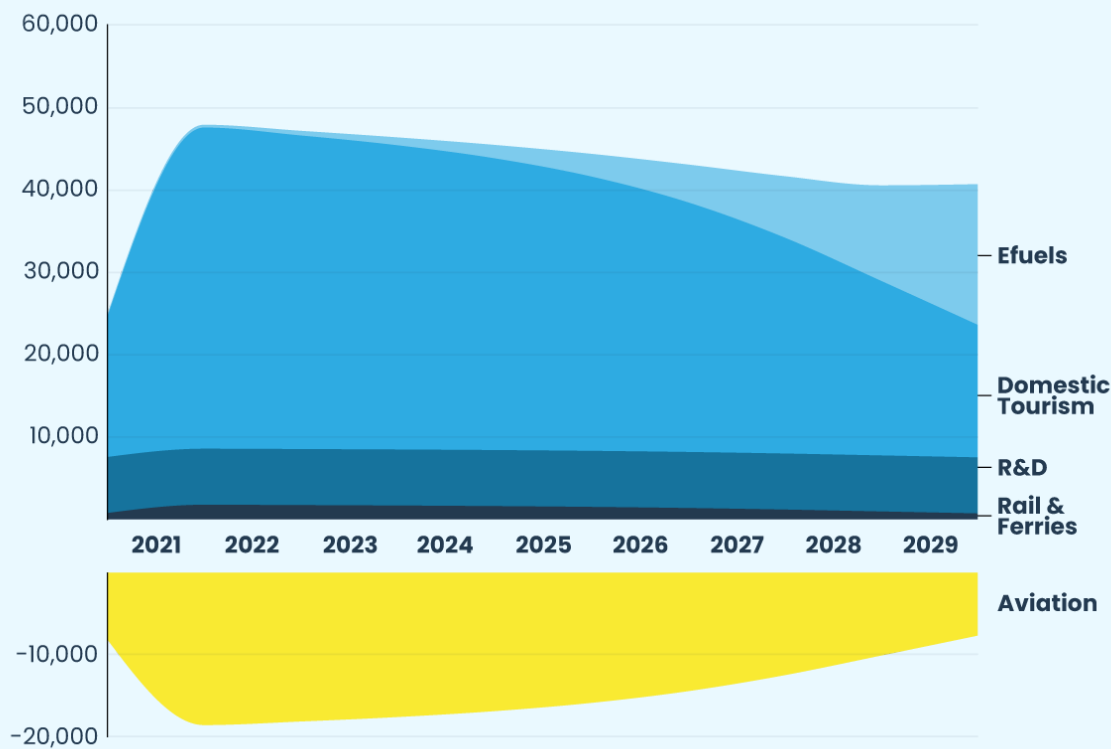


Figure 8: Jobs lost each year in aviation and created in other sectors under the Safer Climate scenario.

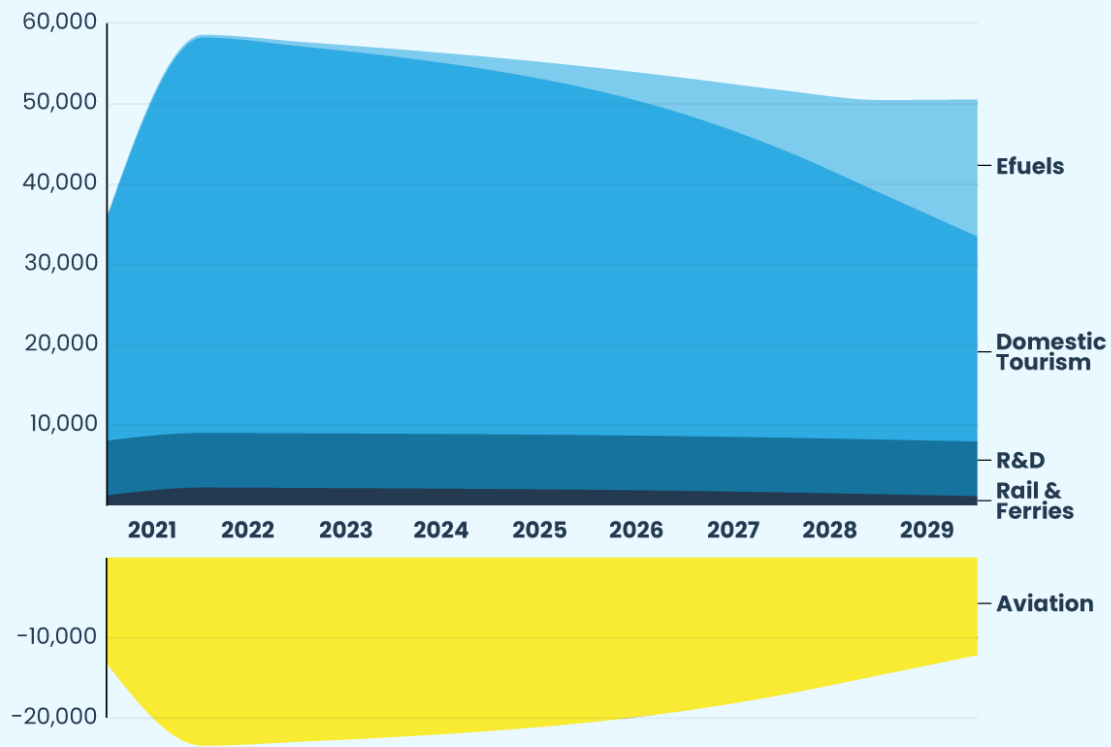
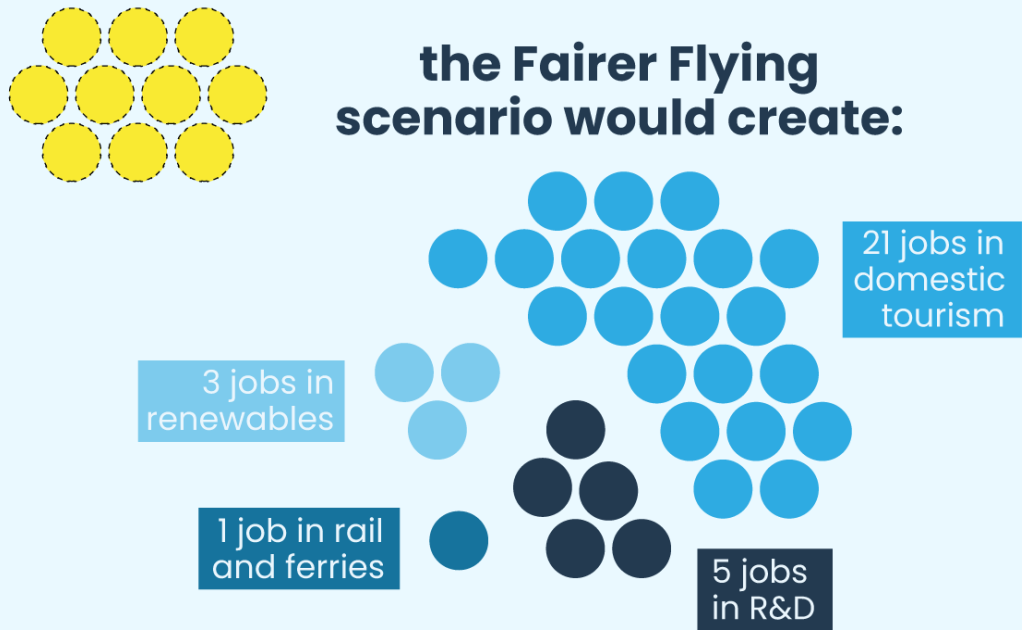


Figure 9. Comparison of jobs lost and gained in different sectors in the Fair Flying scenario.

**For every ten jobs
lost in aviation...**



19. Salaries in the different sectors



We assessed the average salary that is available from a snapshot of roles currently being advertised in sectors outside aviation where new jobs would be created, compared to sector averages within aviation. This is done to give a figure for current and immediately available rates of pay for new jobs in those sectors, rather than rates of pay that applied historically. Doing this finds that, although domestic tourism jobs have lower average pay than aviation, the new jobs being created in low-carbon transport, renewable energy and research and development will pay more than the current aviation sector average. However, given the existence of low-paid and insecure work in the tourism sector, a strategy which includes an increase in domestic tourism as one of the measures needed to reduce aviation emissions would also need to ensure that the roles being created are good jobs, such as by setting a high minimum wage across the economy and supporting sectoral bargaining.

Table 5: Average annual salaries for roles advertised in the different sectors considered.

Sector	Average annual salary
Rail	£42,955 ⁹⁸
Ferries	£47,171 ⁹⁹
Research jobs	£46,839 ¹⁰⁰
Domestic tourism	£29,000 ¹⁰¹
Renewables jobs	£38,252 ¹⁰²
Aerospace	£39,800 ¹⁰³
Airports and support services	£37,400 ¹⁰⁴
Airlines	£30,600 ¹⁰⁵
Aviation sector average salary	£36,475 ¹⁰⁶

Based on roles currently being advertised in the different sectors, the average salary in today's values that would be available across the different roles being created would be £33,375 in the Fairer Flying scenario, and £32,649 in the Safer Climate scenario. While these numbers are slightly lower than current median salaries in aviation, the difference is not huge, and we are looking at the impacts across the economy rather

⁹⁸ ONS (26 October 2021), "Earnings and hours worked, industry by four-digit SIC: ASHE Table 16", SIC Code 4910. At:

<https://www.ons.gov.uk/employmentandlabourmarket/peopleinwork/earningsandworkinghours/datasets/industry4digitsic2007ashtable16>

⁹⁹ ONS (26 October 2021), "Earnings and hours worked, UK region by industry by two-digit SIC: ASHE Table 5", SIC Code 50. At:

<https://www.ons.gov.uk/employmentandlabourmarket/peopleinwork/earningsandworkinghours/datasets/regionbyindustry2digitsicashetable5>

¹⁰⁰ ONS (26 October 2021), "Earnings and hours worked, UK region by industry by two-digit SIC: ASHE Table 5", SIC Code 72. At:

<https://www.ons.gov.uk/employmentandlabourmarket/peopleinwork/earningsandworkinghours/datasets/regionbyindustry2digitsicashetable5>

¹⁰¹ Current average pay from "Tourism" listings on Totaljobs.com, as of 11 November 2021. This best reflects the typical current salary being offered immediately in industry after shock of covid-19, given uncertainties of estimates over last year.

¹⁰² Current average pay from "Renewables" listings on Totaljobs.com, as of 11 November 2021. This best reflects the typical current salary being offered immediately in the industry.

¹⁰³ UK median pay for sub-sector from Airlines UK/York Aviation (July 2021), *Aviation Jobs in Great Britain*, p.6. At:

<https://airlinesuk.org/wp-content/uploads/2021/07/Aviation-Jobs-in-Great-Britain.pdf>

¹⁰⁴ *ibid.*

¹⁰⁵ *ibid.*

¹⁰⁶ *ibid.*

than suggesting that individual workers should move into lower-paid roles. Given the scale of job creation compared to job losses in these scenarios, there would still be a significant net economic (and social) benefit from a modal shift away from aviation.

20. Costs of the transition



Our modelling suggests an annual cost in 2030 of £9.54 bn for the Fairer Flying scenario and £9.58 bn for the Safer Climate scenario, compared to the baseline scenario. These costs include the electricity required for e-fuels use and expanded R&D spending within aviation, along with costs for support and retraining for current aviation sector workers. The government has committed, as of Spending Review 2021, to increase public R&D spending to £22bn from its 2019 level of £10.45bn by 2025/6.¹⁰⁷ Assuming this level of increased spending is maintained to 2030, and that aviation retains its current share of total R&D spending, this suggests that an additional £1.62 bn annually would be available for aviation. In that case, the additional annual costs incurred for the two more climate-friendly scenarios, compared to the baseline scenario, would be only £7.92 bn or £7.96 bn, to cover the costs of the retraining scheme and the clean electricity required for e-fuels.

Before the Covid crisis, the aviation industry's exemption from fuel tax and zero-rating for VAT amounted to a handout each year from the taxpayer to the industry of around £7bn.¹⁰⁸ We suggest that around £8 bn is therefore not an unreasonable amount for the industry to contribute to reduce the harm its emissions cause to the climate, and provide transitional support for people working in the sector.

The UK government has provided guidance on the value of each tonne of carbon which is emitted to be used for policy evaluation, with a central carbon value per tonne in 2030 of £280.¹⁰⁹ The Fairer Flying scenario would reduce tailpipe emissions by 16.5 MtCO₂e compared to the baseline scenario, and the Safer Climate scenario would provide tailpipe emissions reductions of 24.75 MtCO₂e (these numbers do not

¹⁰⁷ House of Commons Library (15 November 2021), "Research and Development funding policy". At:

<https://commonslibrary.parliament.uk/research-briefings/cbp-7237/>

¹⁰⁸ Chapman, A. and Wheatly, H. (June 2020), *Crisis Support to Aviation and the Right to Retrain*, London: New Economics Foundation. At:

<https://neweconomics.org/uploads/files/aviation-workers.pdf>

¹⁰⁹ <https://www.gov.uk/government/publications/valuing-greenhouse-gas-emissions-in-policy-appraisal/valuation-of-greenhouse-gas-emissions-for-policy-appraisal-and-evaluation>

include the additional reductions provided by the use of e-fuels, due to uncertainties in the extent to which they can reduce total emissions, but their use would provide further carbon savings of close to 100%, although they would not be able to eliminate non-CO2 warming).

This suggests that reducing aviation by 50% would generate savings of £4.6bn in the avoided abatement costs that would have been incurred by those emissions, while reducing aviation by two-thirds and fuel burn to a quarter would generate savings of £6.9bn. In both these cases, the avoided costs would largely compensate for additional costs incurred by this transition to cleaner forms of transport.

Appendix A:

Journeys in the modelled scenarios



The following table shows the journeys made in each of the three scenarios, in millions.

	Baseline pathway in 2030	Fairer Flying scenario with 50% transfer of lost flights to domestic tourism	Safer Climate scenario with 50% transfer of lost flights to domestic tourism
Total aviation tailpipe emissions	33 MtCO ₂ e	16.5 MtCO ₂ e	8.25 MtCO ₂ e
Reduction in flights compared to the baseline	0% (baseline)	50% decrease	66.7% decrease
Total international flights departing from UK airports	128.50	64.30	42.87
–of which below 2000km	91.30	45.65	30.43
–of which above 2000km	37.30	18.65	12.43
International flights replaced by intl train journeys	0.00	38.96	27.99
International flights replaced by ferries	0.00	4.24	5.66
Domestic flights	36.80	15.75	9.91
Domestic flights replaced by train journeys	0.00	15.75	19.81
Domestic flights replaced by ferries (i.e. NI – GB)	0.00	5.31	7.08

	Baseline pathway in 2030	Fairer Flying scenario with 50% transfer of lost flights to domestic tourism	Safer Climate scenario with 50% transfer of lost flights to domestic tourism
International trips replaced by domestic trips, ie new domestic tourism journeys	0.00	20.99	27.99
Total outbound flights	165.30	80.05	52.77
Total additional train journeys (replacing flights)	0.00	75.70	99.79
Total additional ferry journeys (replacing flights)	0.00	9.55	12.74
Total journeys	165.30	165.30	165.30
Percentage of total journeys moved from international to domestic journeys		12.70%	16.93%

Note: Emissions numbers do not take into account additional reductions from use of e-fuels in higher ambition scenarios.

All three travel scenarios model journeys departing from the UK only, i.e. not flights departing from other countries to arrive in the UK (so including all domestic flights, apart from military flights which were excluded from the analysis). This is to avoid double-counting emissions, as only one leg of a return flight to another country is included in the UK's emissions inventory. However, jobs were modelled based on total passenger movements at UK airports, with the assumption that total passenger movements were proportional to departing flights.

Appendix B:

Employment modelling data sources and assumptions



We used three sources to understand current employment in the aviation industry, including both those employed directly in the provision of flights, and those employed in ground services essential to the provision of flights, including the large numbers employed at UK airports. National Statistics provide two counts for employment in air travel, taken from the annual Business Register and Employment Survey (BRES). The first is all those jobs classified under Standard Industrial Classification (SIC) code 51, "Air travel". The second is jobs in SIC 52.23 "service activities incidental to air transportation". This classification, however, underestimates total employment related to air transport, since it does not include (for example) retail workers employed at airports. Acuity Analysis have provided a bottom-up estimate for total UK airport employment, which they estimate at 232,966 in 2019.¹¹⁰ This figure is not available as a time series, however, so we used the BRES figures for employment in SIC 52.23 as a proxy for the whole ground employment; it is likely in reality these two series will not change in exactly the same way when passenger numbers change, but the correspondence can be assumed to be close enough for the analysis here.

Taking both the ONS figures for SIC51 "Air travel" and the Acuity estimate for ground staff together give a total employment of 305,000 in UK aviation in 2019, immediately prior to the outbreak of Covid-19.

The modelling here, like any modelling exercise, is subject to a number of simplifying assumptions, which are intended to allow the model to show the central features of the world we are interested in:

- We assume a constant rate of underlying technical change in the industry, identical to the rate as over the decade before 2019, which results in continual

¹¹⁰ Acuity Analysis (2019), "Economic and social importance of the UK's regional airports", London: Unite the Union, p.26. At: <https://www.unitetheunion.org/media/3098/regional-airports-data.pdf>

productivity improvements. These steadily reduce the number of jobs created per passenger carried over time, on the further assumption that the industry remains profit-maximising.

- Similarly, we assume the same rate of capital utilisation applies in the industry, and assume that the relative prices of capital and labour remain the same throughout the modelling period. (Both could change, but we have assumed that the changes do not affect the relative costs of either, and therefore do not change the industry's relative demands for either.)
- We assume sufficient slack in the wider economy so as to meet all demands for labour without shifting the relative price of labour.
- When assessing the indirect (supply-chain) impact of the changes being made here, we do not include the likelihood of changes in relative prices between industries that shift demands. This is a standard feature of the Input-Output (IO) methodology used to assess the relationships between different industries: the impacts are derived from looking at the past structure of inter-industry demands, and are therefore both backward-looking and exclude possible changes in future relative prices as demand shifts.
- We exclude changes in government policy, including taxation, that may affect demand and supply for aviation and its inputs, and we assume no exogenous shocks – further recessions, major wars, further epidemic outbreaks and so on.

The result of these assumptions is to produce a set of scenarios that show the technical feasibility of a transformative shift, without further developing the economic implications. We consider these in the section on policy recommendations, since the implication of a significant technical change in the operation of the aviation industry is that an economic change is also needed: changes to business models and financing, in particular, alongside changes to government policy to support and encourage them.

For the costings, we have conservatively assumed the cost of e-fuels declines to its lower expected level of 3 euros per litre, as suggested by the International Council on Clean

Transportation review of the literature.¹¹¹ We have used the International Energy Agency's latest forecasts for conventional fuel, of a 5.9% average annual increase over the next decade, and taken the current average price for jet fuel as \$88 per barrel.

¹¹¹ Searle, S. (23 June 2020), "E-fuels won't save the internal combustion engine", ICCT blog. At: <https://theicct.org/blog/staff/e-fuels-will-not-save-ice>

Appendix C:

Links to scenario modelling data



A more detailed breakdown of journeys made in the three scenarios is available online here:

https://docs.google.com/spreadsheets/d/1KBabKRv2nWk3QdKjDQyYahDZYnoVAz_CGuaPPg-Jzdo/edit#gid=181054478

Our assumptions on the energy requirements of e-fuels are summarised here:

<https://docs.google.com/spreadsheets/d/1pqJerftCjmRBrSA8wPNn6ysMnt3qrJva7hy3OtpYAJc/>

The numbers for job changes over time are here:

<https://docs.google.com/spreadsheets/d/1yJHhR6TFopB-c7tGQqt4JmTuZCYrVvQI>

Data from the Department for Transport on flight distribution, used to model the Fair Flying scenario, is available here:

<https://docs.google.com/spreadsheets/d/1hHlr7rDRxej7UykJRA-9jjhXyh7B2Khq/>