GRIMSHAW

Aviation Connects the World

GRIMSHAW AVIATION EVIDENCE DOCUMENT

This document seeks to align the current understanding of aviation's impacts on climate change and the opportunities to mitigate these impacts. We have used this analysis to formulate our view as to how Grimshaw could best help support the sector.

Grimshaw believes connecting people and goods by flying has substantial societal benefits.

Grimshaw believes it is essential to keep the world connected through all forms of safe, reliable and efficient public transport, including aviation. The availability of reliable air transport connects people with places, families, knowledge, food, and healthcare through commerce, education, culture and leisure.

Aviation is responsible for the direct and indirect employment of millions and generates numerous economic benefits (see appendix). However, at the time of writing it is predicted that the impacts of Covid-19 means aviation won't return to a normal level of service until 2024. These dramatic impacts have been summarised elsewhere. However, it is worth noting that aviation has been essential in responding to the pandemic. At the height of the pandemic, airlines responded with nearly 46,500 special cargo flights, transporting over 1.5 million tonnes of medical supplies and personal protective equipment. Furthermore, 39,200 special repatriation flights by airlines transported nearly 5.4 million citizens to their homes after borders were closed around the world in March 2020[1].

As the world recovers from the pandemic aviation will be integral to the well-being of the global economy. As we will describe, in this paper there is the opportunity through policy, innovation in aviation technology and broader investment in sectoral decarbonisation to decouple aviation's future growth from its negative impact on the environment.

We recognise that aviation generates significant environmental impacts, both from airport infrastructure and flying aircraft.

Carbon dioxide emissions from aviation amount to 1Gt per annum, which represents about 3% of total global emissions. Non-CO_2 effects, such as warming induced by aircraft contrails and other pollutants, bring the combined total contribution of commercial aviation to approximately 5% of the world's climate-warming problem[2]. In a business-as-usual scenario, emissions could grow to 1.8Gt per annum by 2050[3]. Alarmingly, if other sectors reduce linearly to net zero by 2050, then aviation's percentage contribution could be as much as 50% by 2047[4], making it the greatest contributing sector. Therefore, aviation needs its own contribution to be net zero as soon as possible.

The main challenge lies in passenger travel, which represents 95% of carbon emissions from the sector today, and especially international passenger travel, which accounts for about 60% of emissions[5]. Typically, aviation operates at high load factors, with above 80% passenger occupancy, significantly higher than other modes of transport.

Grimshaw understands the concern that aviation growth will lead to more emissions during a time when all sectors should be decarbonising. Most of the emissions created are associated with flying activities, and airports only

1. https://www.atag.org/our-publications/latest-publications.html Aviation benefits beyond borders 2020 (accessed October 2020)
2. https://www.eesi.org/papers/view/fact-sheet-the-growth-in-greenhouse-gas-emissions-from-commercial-aviation (accessed 14 August 2020)
3. IEA (2017), Energy Technology Perspectives, cited in Energy Transition Commission Reaching net-zero carbon emissions in harder to abate sectors by mid-century http://www.energy-transitions.org/
4. Dr Guy Gratton, Associate Professor of Aviation and the Environment, Cranfield University pers comm. Oct 2020.
5. ITF (2017), Transport Outlook

account for a small proportion of the aviation related emissions. During the global lockdowns caused by the pandemic the aviation sector was brought to a virtual halt, and yet its effects only contributed to a 10% decrease in global emissions[6]. Put another way the 60% reduction in aviation during this period and the subsequent small reduction in emissions highlights the importance of other sectors such as power, vehicle transportation and buildings to prioritise decarbonisation actions[6,7].

We support the urgency to implement decarbonisation strategies in all sectors in order to meet the long-term goals of the Paris Agreement[3]. Whilst industries have different decarbonisation transition timelines, architects and designers need to collaborate and contribute to each sectors' commitment to net zero carbon and regenerative design. And aviation is no different.

Aviation needs to address other challenges, particularly aircraft related noise and air quality; we would expect progressive airport design project opportunities to begin to align with a total net zero approach that is broader than just carbon emissions. This can be better addressed as a component to a master plan for the whole airport. This allows a balanced approach that promotes climate change mitigation and adaptation, as well as stewardship of resources and overall resilience. If our scope is a new terminal, we will advocate for this to be included in our scope.

We are confident that the impacts of aviation can be significantly reduced over time.

We recognise rapid technological advancements and policy stimulus[8] are required to make aviation sustainable. Aside from technological improvements in aircraft design and sustainable aviation fuels we believe further decarbonisation of the aviation sector should also include policy to improve planning of linkages to more connected surface access networks, especially sustainable modes of transport including metropolitan and regional rail. Beyond integration, requirements to reduce domestic flights that compete with rail, as seen in France and the Netherlands, should be a component of governments' plans for their aerospace industry[9, 10].

Funding this transformation will require a viable industry to pay for it, therefore we support an appropriate low-carbon transition, particularly in developing countries which should benefit[11]. There is a focus on electric, electric-hybrid and hydrogen fuelled aeroplanes. Trials are under way with 10-20 seat commercial flights of 500 nautical miles powered by hydrogen, and by 2035 it may be possible for a commercial passenger aircraft to travel 3,000 kilometres miles fuelled by hydrogen[12, 13]. A recent report[14] on the potential of hydrogen-powered aviation predicted such aeroplanes could enter the market as soon as 2035. Current aeroplanes should be initially adapted to burn hydrogen gas for shorter ranges such as London to

6. Temporary reduction in daily global CO_2 emissions during the COVID-19 forced confinement, Corinne Le Quéré, Robert B. Jackson, Matthew W. Jones, Adam J. P. Smith, Sam Abernethy, Robbie M. Andrew, Anthony J. De-Gol, David R. Willis, Yuli Shan, Joseph G. Canadell, Pierre Friedlingstein, Felix Creutzig, Glen P. Peters. Nature Climate Change10, pages647–653(2020).
7. IPCC 2017 https://www.unenvironment.org/resources/emissions-gap-report-2017
8. Depending on the sector growth and national aviation policies, technological transformation to achieve emission reductions of up to 6.27 – 9.18 gigatons CO2 equivalent reduced / sequestered (2020–2050) is achievable with current technologies. Refer to Project Drawdown analysis 'Efficient Aviation'. This analysis focuses on adoption of the latest and most fuel-efficient aircraft; retrofitting existing aircraft with winglets, newer engines, and lighter interiors; and retiring older aircraft early. Note that the Energy Transitions Commission report, Missions Possible: Reaching Net-Zero Carbon Emissions from Harder-to-Abate Sectors by Mid-Century, outlined how improvements in engine and airframe efficiency, along with air traffic and other operational improvements, can significantly reduce the rate of growth in carbon emissions from aviation, but it will not be possible to keep emissions flat, let alone to achieve net-zero carbon emissions by mid-century, without a shift to alternative low-carbon fuels or to electric engines.
9. Coronavirus aid: Air France 'must cut domestic flights to get state loan', BBC News post (accessed May 4, 2020).
10. In March 2020 KLM replaced one of its daily flights from Schiphol to Brussels with a high-speed train transfer. https://www.independent.co.uk/travel/news-and-advice/klm-flight-train-amsterdam-shiphol-brussels-thalys-emissions-a9108446.html (accessed 14 October 2020).
11. A viable and robust aviation sector may not be required to totally fund the technological transformation. National governments might be able to support this transformation alongside required policy work. For example in the UK with Zero Jet fuel https://www.gov.uk/government/groups/jet-zero-council (accessed 24 October).
12. https://www.corporatejetinvestor.com/articles/zeroavias-maiden-hydrogen-powered-flight-approaches-749/ (Accessed 14 October 2020).
13. Quiet and green: Why hydrogen planes could be the future of aviation. Horizon, The EU Research & Innovation Magazine, Article by Jonathan O'Callaghan, July 8, 2020.
14. Hydrogen-Powered Aviation, Independent study, commissioned by Clean Sky 2 and Fuel Cells & Hydrogen 2 Joint Undertakings on hydrogen's potential for use in aviation. June 22, 2020

Vienna. A new generation of aeroplanes with larger fuel tanks to hold hydrogen should be the design goal, then long-haul routes could be divided up to suit refuelling distances. It would mean the redrawing of the global flight route map with new refuelling stations for aircraft.

Hydrogen can be produced at an efficiency of 80% from renewable energy. Creating a hydrogen industry should be part of the post pandemic green recovery. For example, there is huge potential for hydrogen production in the North Sea using deep water floating wind/wave generators since power output is not restricted by voltage drop along power cables. Companies are already exploring this[15].

It should be noted that there are many challenges around aeronautical safety, operational, reliability and the economics to overcome before hydrogen fuel technology is viable. Aviation researchers consider more likely options to be electric or electric-hybrid aircraft serving regional and short-haul domestic, with sustainable fuels gaining more traction for the long-haul markets.

There are research programmes focussed on electric and electric-hybrid (gas) aircraft serving regional and short haul domestic destinations. Currently battery capacity and weight limits flight distances. Moreover, a key requirement for electric planes and indeed other modes of transport, will be the pairing of utility-scale solar PV with battery systems and intelligent software. There is huge potential for affordable utility-scale solar photovoltaic generation around the world[16].

It is worth re-emphasising that improving existing rail infrastructure, as a way of taking vehicles of roads as well as reducing short haul flights should be an important part of the decarbonisation approach[9]. An approach we both support in terms of policy and planning advocacy as well as specifically supporting clients in the design and delivery of this infrastructure. Grimshaw are well positioned to support this strategy.

We realise the decarbonisation transition at airports will vary due to the different challenges that need to be overcome and whilst some Nordic and European airports are looking to be emissions free between 2030-40, the majority of airports will be challenged to meet a long-term net zero carbon goal by 2050.

We believe the aviation sector needs encouragement, and we can help.

Architects have limited ability to influence important technological and policy changes in the aviation sector. However, we do have agency, and Grimshaw is committed to only providing design services in airport infrastructure for clients that clearly demonstrate climate action leadership[17] and meet our design decarbonisation targets.

Our position is shaped by post pandemic politics that are influencing aviation. Evidence suggests aviation is about to go through this rapid technological change, accelerating the sector's ability to deliver low or zero carbon emission flying[18,19]. Recent political decisions and related investments suggest the aviation sector will be able to bring forward its zero-carbon timeline from 2045

15. Dr Rob Miller, University of Cambridge pers comm. August 2020.
16. Project Drawdown Utility-Scale Solar Photovoltaics (accessed 14 October 2020).
17 Examples of climate leadership include, public statements and targets for climate action with disclosure of performance, membership of Airport Carbon Accreditation programme (see page 2) and other recognised groups such as The Climate Group.
18 French government funded research is planned to develop the use of hydrogen for fuel, with a plan to switch to new aircraft fuelled clean energy source by 2035 or thereabouts. The prototype for the new A320 would be revealed around 2026 – 2028, along with a new regional aircraft to be designed before the end of the decade.
19 UK's zero jet council to deliver transatlantic air travel with no harm done to the environment within a decade and is committing funding. https://www.gov.uk/government/news/pm-commits-350-million-to-fuel-green-recovery

to 2035. Whether the slowdown in aviation volumes experienced from March 2020 will continue or not is unclear[20]. The latest projections from IATA predict a mean 3.7% annual growth over 20 years commencing in 2021[21]. Aviation volume may not regain its peak for at least 3-5 years[22]. This provides us with precious time in which the aviation sector can transition into a low carbon sector. We must not waste that time, and Grimshaw believes we can help in the decarbonisation of airport infrastructure.

Grimshaw can best influence the design of the airport: buildings, infrastructure, landscaping and access.

We believe our role is two-fold; firstly, to influence the design of 'on the ground' infrastructure: specifically, airport buildings, masterplans, landscape and transit facilities; and secondly, through our design influence the use, operation and maintenance of the facilities, taking a holistic approach. Not all airports are the same. Some, with large land holdings and controlled environments, landside and airside, have unique potential to pursue net zero and carbon positive strategies. As such, they offer opportunities for the implementation of leading-edge approaches across a comprehensive range of decarbonisation and other sustainable design techniques that can act as demonstration projects which can influence work in other sectors. Other airports are more constrained and require a different set of solutions.

Provided we are working with clients and design teams that share these ambitions, there is much benefit to be gained from working on these projects, especially when they result in the decarbonisation of existing infrastructure.

Commitment to research and development to inform our design work

Grimshaw's design work has always sought to embrace technology, innovation and a respect for the planet and how it functions. We have a commitment to research and development on all our projects. Within aviation we have formed partnerships with leading universities researching the future of flying. We have committed to pro bono support of these research programmes and to sharing our experience in the pursuit of improvements.

We are adopting stringent selection criteria to ensure that we work with clients committed to our aspirations to make airport infrastructure carbon neutral.

We acknowledge that as existing airports upgrade and new airports grow to support economic and social policies, we will need to scrutinise the merits of each project opportunity.

Grimshaw will only pursue aviation projects where the client carbon targets are, at a minimum:

1. aligned with national and international climate goals and commitments,
2. net zero carbon ready[23],

and 3. demonstrate climate action leadership.

Grimshaw will not pursue projects that do not provide enough evidence of a commitment to targets and climate actions. We recognise that sometimes this is unknown at the start of the commission, as part of our work may be assisting clients establish their strategy and target setting. Due to this uncertainty, especially in target

20. It is thought that aviation traffic will not get back to pre-COVID levels until 2024. Cited in Aviation: benefits beyond border. ATAG Sept 2020 https://www.atag.org/our-publications/latest-publications.html (accessed 28 October 2020).
21. https://www.iata.org/contentassets/e938e150c0f547449c1093239597cc18/pax-forecast-infographic-2020-final.pdf (accessed 14 October 2020).
22. How The Airline Industry Will Transform Itself As It Comes Back From Coronavirus, Forbes post on March 30, 2020.
23. Net zero carbon ready is where a design's whole life carbon is understood, reductions of embodied carbon and that associated with operational energy have been made and there is carbon offset required to make it net zero carbon. Targets are dependent on project type (Grimshaw, Net Zero Carbon Framework, unpubl 2020).

setting, we have set our own design decarbonisation targets and will support clients to adopt the following minimum and stretch targets. For any new airports we follow our infrastructure carbon targets that are based on Envision, and for new terminals our carbon targets follow International Living Future Institute (ILFI), Architecture 2030, and the RIBA 2030 guidance [24,25,26,27]. This forms part of our public net zero carbon ready designs by 2025 practice commitment. There are three levels of performance for carbon targets. Target selection will depend on local factors. They are as follows:

Infrastructure carbon reduction targets (new airports)

Net zero carbon ready:
The project team shall achieve a 25% reduction in energy use intensity (operational energy/carbon) from baseline and a 15% reduction of embodied carbon. The offset for 100% of the embodied carbon from the project must be calculated and costed as part of the design team scope. The client may or may not elect to offset.

Net zero carbon:
The project team shall achieve a 50% reduction in energy use intensity (operational/energy/carbon) from baseline with 100% of project's energy must be offset from renewable on- or off-site sources. 30% reduction of embodied carbon from baseline and 100% of embodied carbon offset.

Net zero carbon stretch targets:
Project team shall achieve a > 75% reduction[27] in energy use intensity (operational energy / carbon) from baseline and 100% of project's energy must be from renewable on- or off-site sources. Project team shall achieve a >50% reduction in embodied carbon from baseline with 100% of project's embodied carbon offset.

Buildings carbon reduction targets (new terminal buildings)

Net zero carbon ready:
The project team shall achieve a 25% reduction in energy use intensity (operational energy/carbon) from baseline and a 10% reduction of embodied carbon. The offset for 100% of the embodied carbon from the project must be calculated and costed as part of the design team scope. The client may or may not elect to offset.

Net zero carbon:
The project team shall achieve a 50% reduction in energy use intensity (operational/energy/carbon) from baseline with 100% of project's energy must be offset from renewable on- or off-site sources. Project shall achieve a 45% reduction of embodied carbon from baseline with 100% of embodied carbon offset.

Net zero carbon stretch targets:
Project team shall achieve a > 75% reduction in energy use intensity (operational energy / carbon) from baseline with 100% of project's energy must be from renewable on- or off-site sources. Project team shall achieve a >65% reduction in embodied carbon from baseline with 100% of project's embodied carbon offset.

24. International Living Futures Institute Zero Carbon Standard. https://living-future.org/zero-carbon
25. Institute for Sustainable Infrastructure. Envision. Sustainable Infrastructure version 3.
26. RIBA 2030 Climate Challenge
27. Architecture 2030 Challenge

How our approach aligns with other schemes

Aviation Scope 3[28] GHG emissions are not accounted for in our Net Zero Carbon Infrastructure Framework, but these emissions should be considered by the airport operator, especially if, as we would recommend, the airport owner is following the Airport Carbon Accreditation (ACA) program or other internationally recognised equivalent programmes[29].

This scheme[30] recognises and accredits the efforts of airports to manage and reduce their carbon emissions, with four different levels of accreditation covering all stages of carbon management[31]. ACA is independently administered, institutionally endorsed and has the support of the UNFCCC, the UNEP, the International Civil Aviation Organisation, the US Federal Aviation Administration and the European Commission."

Our Grimshaw adapted targets align with ACA's 'Neutrality' (Level 3+) stage. To achieve this level of accreditation an airport must:

- Fulfil all requirements of 'Mapping', 'Reduction' and 'Optimisation'[32]
- Offset its residual Scope 1 (all direct GHG emissions) and Scope 2 (indirect GHG emissions from consumption of purchased electricity, heat or steam) carbon emissions (GHG Protocol[33]) to show its commitment to achieving carbon neutral operations for all direct emissions and indirect emissions over which the airport has control, using internationally-recognised offsets.

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28. Scope 3: Other indirect emissions, such as: The extraction, production and transport of purchased materials and fuels, Transport-related activities in vehicles not owned or controlled by the reporting entity, Outsourced activities, Waste disposal etc.
29. ACI announces 259 airports now part of Airport Carbon Accreditation program with 10 carbon neutral operators, Passenger Terminal Today News REF website and date accessed
30. Airport Carbon Accreditation website
31. the definitions of emissions footprints used by ACA follow the principles of the World Business Council for Sustainable Development and the World Resources Institute "Greenhouse Gas Protocol" Corporate Accounting and Reporting Standard. When considering the emissions from aircraft within the airport perimeter and on final approach and initial departure, Airport Carbon Accreditation uses the International Civil Aviation Organization's definition of the Landing-Take Off cycle and requires airports to comply with these definitions.
32. 'Mapping' (Level 1) requires a policy commitment to emissions reduction endorsed by top management and the development of a carbon footprint for emissions under the airport's control (i.e., scope 1 & 2 emissions). 'Reduction' (Level 2) requires the fulfilment of all level 1 accreditation requirements, formulation of a carbon emissions reduction target, development of a Carbon Management Plan to achieve the target and annual reduction of emissions under the airport's control (i.e., scope 1 & 2 emissions) versus the three-year rolling average. 'Optimisation' (Level 3) requires fulfilment of all level 2 accreditation requirements, development of a more extensive carbon footprint to include specific scope 3 emissions and the formulation of a Stakeholder Engagement Plan to promote wider airport-based emissions' reductions. 'Neutrality' (Level 3+) requires fulfilment of all level 3 accreditation requirements and offsetting of residual emissions under the airport's control that cannot be reduced.
33. The Greenhouse Gas Protocol (GHG Protocol) defines emissions as direct or indirect.

Appendix: Socio-economic benefits of aviation

In 2019, airlines worldwide carried around 4.5 billion passengers annually with 8.7 trillion revenue passenger kilometres. Sixty-one million tonnes of freight were transported by air, representing 35% of world trade by value, despite being less than 1 % by volume. Every day, more than 128,000 flights transported 12.5 million passengers and annually $65 trillion of cargo[34].

The total economic impact (direct, indirect, induced and tourism-connected) of the global aviation industry reached USD 3.5trillion, some 4.1% of the world's gross domestic product (GDP) in 2018. The air transport industry also supported a total of 87.7 million jobs globally, providing 11.3 million direct jobs. Approximately 1.4 billion tourists are crossing borders every year, over half of whom travelled to their destinations by air. In 2018, aviation supported almost 37 million jobs within the tourism sector, contributing roughly USD 897 billion a year to global GDP[34].

34. https://www.atag.org/our-publications/latest-publications.html Aviation Beyond the Borders 2020 (accessed 14 October 2020).

www.grimshaw.global