Analysis of air transport stake holders perceptions and motivations about long term innovations towards sustainable aviation energy paradigms
ABSTRACT
Aviation sustainability and GHG emissions reduction are academic and social trending topics. Air transport intensive energy use together with its constant pre-pandemic growth and the difficulties to evolve towards non-carbon-based energy paradigms, conform an environmentally "worrying frame".

Emissions reduction initiatives comprise aircraft technology and operation improvements, tax schemes, compensation and trading, efficient infrastructures, and sustainable aviation fuels. All of them have been subject of extensive academic analysis. Aspects that have been almost neglected in this analysis are the personal motivation and commitment from air transport stakeholders to pursue longer term technology developments towards sustainable energy paradigms. This paper explores those aspects by using a novel methodology where experts were interviewed prior to the COVID-19 pandemic (2017-2018) and during the pandemic (summer 2021), aiming at exploring the evolution of their beliefs regarding aviation sustainability, focusing in the expectations regarding aviation energy paradigm changes. Additionally, a survey was run among professionals of the aviation and energy sectors performing a quantitative analysis, triangulated with the interviews’ results.

Aviation professionals keep relying on air traffic recovery and growth despite the COVID crisis. They are also conscious of the difficulties of the sector to enact the application of emissions reduction technologies and policies. However, there is not consensus in the strategies with the highest potential, although some tendencies have been identified: whilst enthusiasm
Objective & Methodology
The objective of the research is to explore the personal motivation and commitment from air transport stakeholders to pursue longer term technology developments towards sustainable aviation energy paradigms. Results derived from a survey among aviation professionals are triangulated with the analysis of in-depth interviews to experts from the aviation and energy sectors carried out prior to and during the COVID-19 pandemic.

Results
Aviation professionals trust air traffic will recover the growth trail, but there is not consensus in the technology and policy strategies with the highest potential for making it sustainably.

Limitations
The study did not investigate the perceptions, motivations and commitments from policy makers and institutional stakeholders regarding aviation sustainability. This will be subject of future research.

Practical implications
Aviation should accelerate the implementation of emissions reduction technologies consensually “at hand”, keep exploring the real scope of longer term technologies and educate society and the air transport sector itself in the value of emissions trading and compensation schemes. About aircraft electrification has cooled down, a higher degree of reliance is put in new engine architectures. Fiscal measures are either poorly valued or not well understood.

Aviation should leverage the consensus on new engine architectures to achieve tangible emissions contention in the mid-term, increase efforts to improve and explain emissions trading and compensation schemes, keep developing new technologies to unveil their real potential, and manage social expectations realistically, stressing its social and economic sustainability dimensions.

Keywords
aviation innovation; sustainability; energy; air transport; climate change; emissions trade systems; digitalization; COVID-19

JEL Codes
O33; O44; R41
1. INTRODUCTION

Along the last six or seven decades and up to the first quarter of 2020, air transport had experienced a continuous development sustained by two indisputable paradigms:

- The sustained growth demand, driven by the also indisputable motivation of the public to travel in their search for happiness through changes and novelties (Ram et al., 2013).
- The use of gas turbines for jet propulsion, relying on high energy density fossil fuels as the main energy source (Hernández, 2008).

Social and academic discussions about aviation sustainability had for years questioned the viability of maintaining those two paradigms, and potential alternatives have been analysed (Christensen, 2016; Gascón Gutiérrez, 2013; Gössling et al., 2010; Gössling & Cohen, 2014; Hall, 2010; Peeters et al., 2016). But factually, they remained “unaltered” until the spring of 2020, where two simultaneous and, in principle, unrelated events took place:

- Irruption of the COVID-19 pandemic in the global scene, causing a brutal decrease of air traffic (International Civil Aviation Organization (ICAO), 2020; Japan Aircraft Development Corporation, 2020), momentarily killing the first (growth) paradigm and creating incertitude about its future development.
- Flourishing of new technology proposals for aviation energy paradigm change in the frame of an acceleration of governmental, institutional and sectorial sustainability commitments, in particular related to emissions reduction (or even their deletion), thus creating an exacerbated need to challenge the second (energy) paradigm as well as finding the right policies towards a sustainable aviation (Amankwah-Amoah, 2020; Gössling, 2020).

In late 2020 and early 2021 Jiménez-Crisóstomo et al. (2021) analysed whether the same constraints that were sustaining the jet engine fed by fossil fuel energy paradigm preventing its change in the pre-COVID scenario were still applicable in the pandemic scenario and/or whether there were new constraints. Irrespectively of their conclusions, they pointed out the importance to explore the beliefs of aviation, energy and tourism stakeholders in the new pandemic scenario (and as much as possible in contrast to pre-pandemic views) with regards to attaining relevant air transport paradigm changes enabling a significant aviation GHG reduction in the midterm. This paper aims at characterising said views by a mix of qualitative (comparison of pre and during pandemic in depth interviews with experts) and a quantitative (descriptive analysis of the results from a survey run through aviation, energy and tourism stake holders), which a is a fundamental methodology novelty, moreover in the air transport field. Ultimately, specific recommendations are drawn in view of the analysis of results.

2. THEORETICAL BACKGROUND

In spite of the limited contribution of aviation to global GHG emissions (between 2 and 3% depending on the source, and with an overall effect of 3.5% of the human caused climate change according to ATAG Air Transport Action Group (2020), air transport is socially perceived as non-sustainable activity as a consequence of its high energy intensity. There is nowadays a proliferation of comparisons among different transportation modes, shaming aviation for its high energy consumption in relative terms (see for example Dalla et al., 2017). Since this is an unavoidable physics constraint (flight requires lifting elements moving at high speeds, and required power goes with the cube of speed), the only chance for aviation to become emissions friendly, on top of achieving higher efficiencies all across the system, is
either in evolving its energy paradigm or in compensating its emissions transversally to other sectors by means of emissions compensation and trading systems.

Efficiency improvements are continuously pursued by all stakeholders since they yield not only environmental benefits, but increased business profitability. But after decades of system enhancement, the remaining scope for improvement without paradigm changes is limited.

Although a useful tool, many academics have expressed concerns on trading and compensation systems having a very limited effect in emissions reduction (Gössling & Lyle., 2021), as well as on the uncertainty about its future extent of application (Maertens et al., 2019; Scheelhaase et al., 2018; Efthymiou & Papatheodorou, 2019).

The alternatives currently discussed in the industry to evolve on the traditional aircraft energy paradigm (fossil fuel combustion jet engine) are:

- SAF (Sustainable Aviation Fuels), being either:
  - Biofuels from diverse feedstocks (Benito & Benito, 2012):
    - alimentary species (such as palm or corn), dedicated species (such as jathropa and cameline), algae, solid municipal waste, vegetable waste ...
- Aircraft propulsion electrification and hybridization.
- Hydrogen based propulsion:
  - By electric motors using fuel cells (Sürer & Arat, 2018).
  - By hydrogen burning gas turbines (Corcher & Montañés, 2005).

The SAF options are, in principle, compatible with current aircraft and engine architectures, while electrification and hydrogen require significant architectural changes.

The propulsion industry is also pursuing new revolutionary architectural concepts such as the UltraFan© (Haselbach, 2019) and the Propfan (Maoui, 2016), with moderate impact in aircraft design in the case of the UltraFan© and a more severe impact on aircraft architecture for the Propfan, although maintaining the combustion gas turbine paradigm in both cases.

Jiménez-Crisóstomo et al. (2021) discussed the current applicable limitations for the different technical proposals as well as provided an overview of their maturity. The perceptions from stakeholders subject to prospection in the current paper will be in fact highly dependent on their degree of knowledge of said limitations and maturity. However, by no means is this research intended to test stakeholders knowledge in these key issues, neither to educate them in any way.

Regarding the use of qualitative methods in aviation sustainability research, in depth interviews with sectorial leaders is a tool widely used for producing sectorial reports and projections (i.e., McKinsey & Company, 2020; ATAG Air Transport Action Group, 2020), but it has been seldom used by academics. Gössling & Scott (2018) explored the understanding of the tourism sector with regards to the decarbonization challenge by interviewing 17 senior tourism leaders examining their perspectives in terms of “belief systems” as well as forms of agnogenesis. They concluded that, even though there was consensus among tourism leaders in recognizing that climate is already changing, they had disparate views on how the problem should be tackled. Moreover, they detected that some of the tourism leaders had perspectives not supported by scientific evidence, which represents a major barrier for the tourism sector to embrace low-carbon commitments. Focusing more specifically in aviation impacts, Leamon et al., (2019) analysed the effects of climate change in commercial airlines as well as the potential actions that airlines could take (individually or as a sector) to resolve
them by analysing existing literature and interviewing airline and tangential industry executives, to conclude that airlines are already suffering the effects of climate change while they are also working on measures to mitigate their impact, with a specific mention to adherence to CORSIA (Carbon Offsetting and Reduction Scheme for International Aviation programme from the International Civil Aviation Organization). However, the question on whether those efforts will be sufficient to achieve a low-carbon industry in 2050 remains open.

3. RESEARCH METHOD

The academic literature review on aviation sustainability reveals that researchers have almost neglected the analysis of the personal motivation and commitment from air transport stakeholders to pursue longer term technology developments towards sustainable energy paradigms and their confidence in their success as well as the real adherence of sector stakeholders to published sustainability institutional policies and goals. Understanding said motivations and adherence is fundamental to assess the credibility of the different scenarios proposed and discussed by aviation private and institutional stakeholders. Due to the complexity of the issue and the need to frame it in an evolving context, the proposal in this research consists of a mixed quantitative-qualitative methodology that allows for triangulation of results.

3.1. The qualitative method

In-depth interviews with experts from the air transport, energy and tourism sectors were performed prior to the pandemic (in 2017 and early 2020, in the frame of an earlier research) and during the pandemic (summer 2021), which allows for comparing stakeholders’ perceptions under those substantially different scenarios.

3.1.1. Interviews methodology

Interviews are a suitable tool for this research as the conditions described by (Taylor & Bogdan, 1984)) for its application are met: the goal is well defined, there is a fundamental interest in capturing subjective perceptions, it is difficult to access to the interviewees in their sectorial role by participant observation (although not impossible; refer to Jiménez Crisóstomo (2020) discussion about participant observation through attendance to seminars, congresses and open workshops), the research depends on a wide range of sectors and stakeholders, and time limitations apply (in part due to the evolving nature of the subject). For the pre-pandemic interviews a range of interview types was deployed (non-structured vs semi-structured; individual vs group; live conversation vs e-mail written responses) as one of the goals of that earlier research was precisely to compare the suitability of the different types as well as the participant observation for this matter (Jiménez Crisóstomo, 2020). Relevant conclusions were derived regarding a higher tendency to produce “corporate vectored answers” when interviews were semi-structured, in group and by e-mail.

For the in-pandemic research a semi-structured interview approach has been adopted to allow for an easier comparison with the pre-pandemic set and to ease its connection with the survey supporting the quantitative analysis. A few questions were added with respect to the original set in order to consider relevant events occurred along the time span, namely:

- Irruption of “flight shame” in the social scene (Gössling et al., 2020).
- Irruption of hydrogen based technologies for aircraft propulsion in the aviation sustainability debate (European Commission, 2020).
- Flourishing and spread of digitalization technologies and policies, as well as application of industry 4.0 principles to the aeronautical industry (Guyon et al., 2019) and the consequent debate about its impact in sustainability (Bonilla et al., 2018).

- Certainly, COVID-19.

It needs to be noted that the original interview guide was mainly focused on understanding perceptions regarding aviation sustainability from an energy standpoint. However, the research team decided to maintain the original questions in spite of the wider scope of the current research (looking into overall aviation sustainability) to allow for an easier comparison of the answers and knowing that the interviewees would offer their views in environmental aspects of aviation as well.

The reports of the interviews were written and offered to the interviewees for review and comments before final issue, ensuring their testimony was rightfully captured.

The interview guide is included in Appendix 1, with the in-pandemic added questions marked in red.

3.1.2. Interviews base

Eight individuals were interviewed twice, prior and during the pandemic, and a comparison of their testimonies was performed aiming at detecting and assessing changes in perceptions about expectations regarding the potential of the different technology proposals and policy measures and their degree of deployment – efficiency in mitigating aviation emissions.

Interviewees where chosen based on accessibility and representativity criteria. All of them are professionals with a wide and proven experience in the aeronautic and energy sectors, or academics in those areas, with many instances of individuals with experience in multiple fields. Furthermore, the authors are fully confident in the suitability of the interviewees for the research since their background and professional trajectory is not only known, but has been historically witnessed. The eight interviewees cover experience, at senior, even executive level in top multinational companies and universities (refer to table 1 for a summary of interviewees experience by individual) in the following fields:

- Aeroengines research and design & make companies, as well as international engine consortiums.
- Aircraft research and design & make companies, including engineering as well as business development, with participants from two main competitors.
- Aeronautical systems engineering and design & make companies.
- Senior academics with professional background in aeronautics and energy.
- Renewable energy, both development and consultancy companies. Participants with this profile had also background in aeronautics.

In-depth interviews with experts from the aviation, energy and tourism sectors were carried out in 2017, reported and analysed by Jiménez Crisóstomo (2020). At the time, prior to the pandemic and to the irruption of new technology proposals for aviation sustainability, the experts concluded that renewables and nuclear energy would carry on gaining share over fossil fuels, but that, at the same time, was impossible to materialize a change in the aviation energy paradigm in the mid-term. However, the energy and aviation experts remained positive with regards to aviation development and growth, since the improvements in other sectors would guarantee the availability of fossil fuels for aviation as well as the required global emissions attrition, while the aviation industry would keep working on alternative technology solutions that could be made available in the longer term. Tourism experts concluded that climate change will significantly affect tourism patterns and
distribution but would probably not have a significant impact at aggregated levels, and that an aviation crisis would take an important toll on tourism to insular states and destinations as well as on intercontinental travel.

The interviews base was further extended in 2018 and 2019, yielding similar views and conclusions.

In summer 2021 a second round of interviews was carried out with the aim to compare the evolution in the perceptions of experts from the aviation and energy sectors upon the change of scenario induced by COVID-19 and the new technology proposals. Table 1 details the interviews supporting this extension of the study.

3.2. The quantitative method
3.2.1. Questionnaire development
For the quantitative analysis, a questionnaire has been elaborated considering the methodology and recommendations from the UNWTO (Perez et al., 2008) and as per the following process:

- Previous research allowed the authors to exhaustively pre-identify technologies, policies and socioeconomic circumstances relevant to the aviation sustainability, therefore capturing those in a draft questionnaire.
- Completion of a first set of 3 interviews allowed for further refinement of the questionnaire enlightened by the answers from the experts.
- The questionnaire was tested by inviting the attendees to the course “Avances y desarrollo del sector aeronáutico y aerospacial. VII Edición” (Universidad de Verano de Teruel) to fill it in while one of the authors of this research was lecturing on “The future of aeronautic propulsion” (Universidad de Verano de Teruel, 2021). The test was fully satisfactory, with respondents (up to 12) answering all the questions soundfully, highlighting no issues in their understanding or interpretation. A subsequent test was done by offering the questionnaire to the fourth interviewee, and again, the result was fully satisfactory.

The final questionnaire can be found in Appendix 2. It is composed of 28 questions covering five conceptual blocks (not coincidental with the questionnaire structure):

- Sociodemographic.
- Exploration of individual degree of concern and attitudes towards sustainability.
- Assessment of technologies and policies for aviation emissions reduction.
- Assessment of the effect of transversal factors for aviation emissions reduction, including COVID-19.
- Summary of expectations about aviation sustainability.

3.2.2. Survey completion and final sample
The survey was elaborated using Survey Monkey and electronically submitted to professionals from the air transport, energy and tourism sectors. Respondents were asked to further distribute to their colleagues and acquaintances within those sectors, which helped to collect a wider response base at the expense of losing some visibility of the relevance of the respondent (knowledge about the matter, decision making capability). Collection of responses took place during July and August 2021, in a context framed by COVID-19 and its induced effects: infection waves, economic recession, travel restrictions, financially troubled airlines and manufacturers, etc.

A total of 150 answers were collected as a result of a prospect for responses in diverse forums (professional associations, academic communities, personal acquaintances, former and present business partners ...) and using different means (printed ques-
tionnaires, e-mail distribution, Whatsapp groups, posts in social media such as LinkedIn and Facebook).

4. COMPARATIVE ANALYSIS OF THE PRE-PANDEMIC AND PANDEMIC SCENARIOS

4.1. Background
Jiménez-Crisóstomo et al. (2021) analyse and discuss the different constraints limiting the ability of the air transport sector to progress in the introduction of new technologies capable of achieving a substantial reduction of GHG emissions. Said analysis takes into account market conditions (from the demand as well as aircraft supply stand points), new aircraft development times, technology maturation lead times, applicable technology state of the art and limitations, as well safety and certification requirements), and it is performed in two substantially different scenarios:

- The pre-pandemic scenario of continuous air traffic growth, supported by saturated aircraft build lines and component manufacturing suppliers, where the technology development debate is focused in new engine architectures, aircraft electrification and hybridization and the use of biofuels.
- The pandemic scenario, started in March 2020, of demand recession, financial scarcity, uncertain recovery prospects, aircraft orders cancellations and postponements, early aircraft retirements; where new technology proposals in support of aviation sustainability flourish such as the hydrogen powered aircraft (either by means of fuel cells or by direct combustion into a gas turbine)

Table 1. list of interviews to experts from the energy and the aeronautical sectors pre- pandemic and during pandemic. Initials do not correspond to real names for the sake of keeping participants anonymous

<table>
<thead>
<tr>
<th>Interviewee</th>
<th>Sector</th>
<th>Pre-pandemic interview month-year/type</th>
<th>Pandemic interview month-year/type</th>
</tr>
</thead>
<tbody>
<tr>
<td>SD, vicepresident at an aircraft manufacturing company</td>
<td>Aeronautical Industry</td>
<td>06-2017/Semi-structured</td>
<td>08-2021/Semi-structured</td>
</tr>
<tr>
<td>WI, senior business development at a renewable energy company, with prior experience in gas turbines and engines</td>
<td>Energy/Aeronautical Industry</td>
<td>04-2017/Non-structured</td>
<td>08-2021/Semi-structured</td>
</tr>
<tr>
<td>BM, engineering director at an aeronautical design and manufacturing company</td>
<td>Aeronautical Industry/Academia</td>
<td>05-2017/Non-structured</td>
<td>07-2021/Semi-structured</td>
</tr>
<tr>
<td>JH, senior manager at an aeronautical international consortium</td>
<td>Aeronautical Industry/Air Transport</td>
<td>05-2017/Semi-structured</td>
<td>07-2021/Semi-structured</td>
</tr>
<tr>
<td>JV, director at an aeronautical systems company</td>
<td>Aeronautical Industry</td>
<td>05-2017/Non-structured</td>
<td>07-2021/Semi-structured</td>
</tr>
<tr>
<td>BW, university professor with extensive background in the energy and aeronautical industry</td>
<td>Energy/Aeronautical Industry/Academia</td>
<td>05-2017/Non-structured</td>
<td>07-2021/Semi-structured</td>
</tr>
<tr>
<td>BN, executive director at an engineering services company</td>
<td>Aeronautical Industry/Air Transport/Energy</td>
<td>11-2018/Semi-structured</td>
<td>07-2021/Semi-structured</td>
</tr>
<tr>
<td>KS, senior specialist in aircraft systems and entrepreneur in renewable energies</td>
<td>Aeronautical Industry/Air Transport/Energy</td>
<td>03-2019/Semi-structured</td>
<td>08-2021/Semi-structured</td>
</tr>
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</table>
and the synthetic fuels produced relying on renewable energy consumption.

The conclusions of the study remarked that, even if there are very significant differences between both scenarios, in both cases the expectations for achieving a relevant reduction of aviation emissions in the mid-term (2040) remain modest; and they identified the changes in engine architectures as well as the emissions trade and compensation schemes as the mechanism with higher, yet modest, potential effect in aviation emissions control in the mid-term. The Jiménez-Crisóstomo et al. (2021) study also highlighted the need to further “explore the real adherence of sector stakeholders to sustainability institutional policies and goals as well as their degree of personal motivation, commitment, and belief to pursue the new industry technology proposals”.

The present research is a first step of said exploration, aiming at contrasting whether the overall perception of the stakeholders is consistent with the conclusions derived from the Jimenez-Crisóstomo et al. (2021) study.

4.2. In-depth interviews analysis
The in-depth interviews performed before the pandemics have been compared with those carried out in summer 2021 for each individual looking for identifying whether interviewees’ perceptions about air transport sustainability perceptions had evolved or remained fundamentally the same.

BN:
- BN remains sceptical regarding the causality of GHG emissions growth in climate change. However, he also keeps his statement about the CO2 emission index being an extremely useful KPI (Key Performance Indicator) that provides valuable information about the efficiency of policies and technology developments in reducing production of other harmful pollutants as well as consumption of valuable resources. In spite of the scenario change, he still perceives the scenario “optimistic 2” (refer to appendix 1, in scenario “optimistic 2” aviation benefits from progress in alternative energies use in other sectors, releasing the pressure on fossil fuels use and thus postponing any potential crisis, keeping them available for aviation, allowing for aviation to further evolve in longer term technologies) as the most likely. Moreover, he keeps his view of aviation having a very limited impact in global GHG emissions and his support to nuclear plants as a source of clean energy.

- BN also remains sceptical about the potential of the current technology proposals for aviation emissions reduction. In spite of being the only interviewee that gave some credit to hydrogen powered aircraft during the pre-pandemic interview, his view in summer 2021 is that hydrogen better suites land transportation and energy production, with its application to aviation being limited to small aircraft and requiring very long development times for both aircraft and supporting infrastructures. Moreover, he does not see any of the other technologies as viable in the mid-term for a wide deployment in the overall aviation industry. He gives some credit to some electric applications (like Lilium, see Nathen et al., (2021)) with very limited payload and range, constituting a new product rather than an alternative one. No matter the limitations, he supports the investment in exploring new technology pathways understanding that some solutions may end up being discarded and some other simply required longer development times.

- While trusting in a rapid traffic recovery (quicker for short and medium range, slower for long range) in the wake of COVID-19, he believes that business travel will not recover to the pre-pandemic levels and expressed some concern that negative perceptions about aviation driven by politically biased groups may derive into legislation and fiscal measures drastically limiting the general
population ability to travel and castrating the invaluable social, cultural and economic benefits of travelling.

- He relies on digitalization as a key driver for aviation sustainability, since it will allow for more efficient aircraft production and operations.

**JV**

- In summer 2021, JV repeats most of his messages from 2017. In particular, he reiterates the need for extended technology development times in aviation due to the extremely strict safety requirements and insists in the idea of the industry sending excessively positive messages about aviation sustainability expectations in many instances with political purposes. He keeps on seeing higher potential for the use of alternative energies in other sectors (rather than in aviation) and puts significant reliance on nuclear power.

- JV also favours scenario "optimistic 2" as the most likely for the future of air transport. In fact, he has developed a more optimistic perception compared to 2017, as he believes that the air transport industry is really reactive and sensitive to social demands, as well as to the fact that fuel consumption reduction is not only an environmental goal, but also economic. He has evolved to clearly expressing little faith in electric aviation and identifying a higher potential in SAF (Sustainable Aviation Fuels) and hydrogen-based propulsion.

- Regarding digitalization, JV reckons that it will help to achieve efficiency improvements in aviation, but will not be a key element so as to enhance an energy paradigm change.

- JV trusts passenger motivation and the wish to recover the lost time will push a rapid recovery of air traffic (that will not be full for business travel). However, the time scales of the pandemic are not really understood and introduce a great level of uncertainty; and will certainly impact on the costs and prices.

**BM**

- BM continues perceiving the difficulties to apply alternative energies to aviation as significantly higher compared to other sectors and the impact of aviation in global emissions as really minor. Consequently, he maintains his adherence to scenario "optimistic 2" as the most likely to the future of aviation.

- However, he has significantly changed his views regarding the viability and potential of the different technology proposals for containing aviation emissions:
  - His reliance in electric and hybrid-electric systems for global emissions reduction has gone down.
  - He now favours SAF (Sustainable Aviation Fuels), expressing a higher confidence in synthetic fuels potential compared to biofuels.
  - He relies on combustion gas turbines as the only viable solution for most of the air travel. Making them sustainable would require operating them either with SAF or hydrogen in the longer term.
  - He has improved his perception about Propfan as a feasible solution.

- BM does not see digitalization as a key factor in aviation sustainability, although it reckons it can help to achieve more efficient aircraft operations and manufacturing.

- As COVID-19 effects decrease, BM expects a quick traffic recovery keeping the traditional correlation with GDP growth. However, he reckons that some socio-politic movements may lead to instating taxes and demand limiting laws having a negative impact in the demand.

**BW**

- BW keeps remarking the technical goodness of fossil fuel engines in terms of energy density, power and compacity compared to other alternative energy systems, therefore their extreme
advantage for aviation applications. He also insists in nuclear energy being the most suitable for achieving a significant increase of energy availability with a more limited consumption of resources. In any case, he maintains his view from 2017 that, unavoidably, limitations in resources will lead to a change in lifestyle as the population keeps growing as it also does its aspirational well-being.

- BW state that a paradigm change in aviation propulsion, such as hydrogen powered aircraft, will take 1 or 2 generations (25 to 50 years). He expresses no reliance in bio or synthetic fuels since their production imply a gigantic consumption of resources.
- In BW’s view, digitalization will help improving aeronautic systems efficiency, but will not be key in changing paradigms. Flight is about aerodynamics and propulsion, not IT.
- BW believes that scenario “optimistic 2” is the more likely, but also reckons that in the longer term, it will evolve towards the “intermediate” (higher air transport prices causing an attrition in demand).
- He stresses his deep distrust in current politicians’ continuous attempts to impose a non-viable reality by means of irrational laws.

JH

- In summer 2021, JH remains positive with regards to the ability of the aviation sector to achieve a contention of its emissions. Moreover, she perceives the COVID-19 traffic reduction as an opportunity to gain time for technology development.
- JH keeps relying on electrification as the main pathway to aircraft emissions reduction, pointing out that it is already a reality for small aircraft. She also expresses being deceived by the poor evolution of biofuels since the original interview in 2017.
- She heavily relies in the “enhancing effect” of digitalization, allowing for quicker turnaround times in aircraft design and technology developments.
- She favours scenario “optimistic 2”.
- Her expectations are that traffic will recover in 2-3 years, with business travel suffering a permanent reduction. Although she recognizes that social movements such as flight-shame will have an impact in government action and measures, she trusts that, globally, passenger motivations will not change neither it will traffic.

KS

- KS keeps on having very limited confidence in the potential of hybrid and electric propulsion systems for aircraft application, and also remains very concerned about the long lead times that the definition of certification requirements for new technologies and aircraft architectures could take and the absence of life cycle cost analysis when decision makers define technology development rout-maps.
- He is still convinced that the future air transport scenario will feature a certain degree of demand attrition as a consequence of the internalization (one way or another) of environmental costs.
- KS has embraced, although with some reserves, the sustainable synthetic fuels as a technically viable solution for aviation sustainability, although recognizing that their impact in demand and market neither the scalability of production are not well understood yet. He judges that their introduction in air transport is by far much easier than hydrogen-based platforms, since these require significant aircraft architectural changes as well a simultaneous development of the supporting infrastructures.
- KS has evolved from a preference for the “intermediate” scenario in 2019 to an “optimistic 2” scenario in summer 2021, noting that it may easily evolve towards “intermediate”.
- In the last years he is developing a growing concern on lack of rationality and analysis in imposed policies leading to unattainable commitments from the industry (air transport as well as other sectors) related to emissions reduction goals.
So, in summary, most of the experts (BW, JV, BM, KS, BN, JH ...) from the energy and aeronautic sectors concur with scenario “optimistic 2” (aviation benefits from progress in alternative energies use in other sectors, releasing the pressure on fossil fuels use and thus postponing any potential crisis, keeping them available for aviation, allowing for aviation to further evolve in longer term technologies) as the most likely for the mid-term future of aviation, with many of them considering nuclear power (BW, JV, BN) as a key element to cleanly replace fossil fuels to cover energy demands in sectors other than aviation. This is consistent with their views expressed in 2017 to 2019 interviews, although in summer 2021 some of them (BN, KS, BW, BM) have developed a relevant concern on said scenario potentially evolving to “intermediate” (reduced fossils fuels availability impacts on fuel costs and thus in air ticket prices, causing an important attrition in air transport demand) as a consequence of poorly defined policies rather than due to a real scarcity of fossil fuels.

Their assessment of the new circumstances concurring in the 2021 scenario is also very consistent. There is no reliance on the new technology proposals getting a significant development and fleet deployment in the mid-term. Reliance on electric or hybrid-electric solutions for achieving a significant reduction of aviation emissions remains low (only JH keeps her perception of high potential) and has in fact decayed for some experts (JV, BM, KS), although most of them reckon their suitability for new products and services covering low payloads and short ranges in interurban applications (BN, JH), but having an insignificant impact in overall aviation GHG emissions.

Most of the experts support keeping investigating all technology options to understand their real scope of application and limitations (JV, BN, KS), and reckon that some technologies will require longer development times due to their higher impact on aircraft architecture and to the need to simultaneously develop infrastructures, production scales and logistics in support of their operation. In that sense KS and BM perceive synthetic/sustainable fuels as a reasonable alternative for the mid-term since its impact in aircraft systems and architecture is very limited. On the other hand, BW really rejects the viability of the synthetic fuels based on the gigantic consumption of energy required for their production. None of the experts expressed confidence in biofuels.

The experts do not deny the viability of hydrogen-based propulsion, but reckon that their development can only happen in the long term (1 or 2 generations – 25 to 50 years for BW).

All experts from the aeronautic industry feel unfairly accused by society of heavily contributing to GHG emissions and climate change, while, in reality, aviation contribution to global emissions is relatively very small.

The perception of digitalization as a relevant factor to improve manufacturing and operations efficiency is generalized, although most of the experts believe it is not a key enabler for aviation sustainability or for an energy paradigm change (except for JH).

Views of the recovery of air traffic in the aftermath of COVID-19 are also significantly consistent, with an overall conviction that traveller motivations will drive the recovery, overcoming the potential negative impact of social movements like flight-shame, but with a permanent not full recovery effect for business travel.

Most of the interviewees had little or even no knowledge about the emissions trading and compensation schemes, although some (KS) reckoned a good potential based on the fact that they imply an internalization of the aviation external effects.
5. Analysis of Current Expectations for the Future Through the Results from an Extended Survey Among Aviation Professionals

The 150 answers collected allow to perform a sound descriptive analysis, although in some cases the research team had to give up on characterizing results according to some socio demographic variables as a consequence of not having wide enough samples for some classes. In any case, the survey remains open with the expectation to collect a wider response range in the upcoming weeks.

Table 2 summarizes the sociodemographic characteristics of the sample.

More than 87% of the respondents are over 30 years old, which allows to assume that the respondents accumulate a significant professional experience and knowledge in their sectors. There is a very significant difference between the number of female and male respondents. This is most probably due to the intrinsic existing gender employment differences in the aeronautic sector. For example, EUROSTAT data (EUROSTAT, 2021) about air transport employment in Spain (country where most of the respondent are original from) in 2019 show a 58.9%-41.1% male-female distribution. This difference is further exacerbated when focusing on senior roles (which is likely to be the case for many respondents as per their age and experience). For example, when examining the distribution of senior executive roles in the airline industry by gender, it is found that only 14% are women (STATISTA, 2021). There are initiatives in the sector to promote women employment in aviation, such as “The Air Transport Gender Equality Initiative” (ICAO, 2016b) launched by ICAO in support of Resolution A39-30 “ICAO Gender Equality Programme Promoting the Participation of Women in the Global Aviation Sector” (ICAO, 2016a).

It can be observed that the vast majority of respondents correspond to the academia, air transport and aeronautical industries, so the conclusions will be mostly relevant to these sectors. An opportunity for future work is identified in further deploying the survey to capture more responses from the tourism and energy sectors.

Table 2 shows that there is a preponderance of technical academic backgrounds among the respondents (68%), while it is also observed that work profiles are equally balanced between technical (50.7%) and rest of profiles (management, sales and other). This result is particularly encouraging for the investigation since it implies that, on top of wide experience in their fields, many of the respondents have technical background knowledge as to reasonably build their own criteria with regards to the viability of the different aviation technical solutions under discussion. The fact that a significant number of these academic technical backgrounds have evolved into managerial positions makes them even more suitable to build a holistic view of the potential of the technology and policy proposals for aviation sustainability.

Respondents had seven different nationalities, although the vast majority corresponds to Spanish nationals (91.3%). Future studies should seek for an extension of the sample to collect more international data in order to allow for analysing the influence of nationality in the variables of interest.

5.1. Analysis of stake holders’ sensitivity to sustainability in general and to sustainability of aviation and tourism in general

Figure 1 summarizes the results of the answers to the block related to individuals concern about sustainability and their assumption of personal sustainable behaviours.
The respondents expressed a high degree of concern about sustainability in general (mean 7.57/10) and very slightly lower about aviation and tourism (mean 7.37/10). However, their rank at lower levels their own assumption of personal sustainable behaviours (7.06/10), and even significantly lower when travelling (6.37/10). This is in fact consistent with previous social studies. Ram et al. (2013) describe how travellers, in their search of happiness through changes and novelties by creating distance with their routines, run into a conscious unsustainable vacation behaviour creating a gap with their environmentally friendly everyday behaviours.

It is also remarkable that, in spite of the uniformity of nationality, education levels and professional sectors and profiles, the dispersion of the answers is significant, with standard deviations around 2 in all cases.

### 5.2. Analysis of reliance on technology proposals and policy measures

Table 3 summarizes the reliance of the respondents to the different technology and policy options proposed to achieve a significant reduction of emissions in aviation.

All options proposed are scored means higher than 5, with the highest scores corresponding to new engine architectures (7.59/10), air traffic control and navigation improvements (7.42/10) and more efficient infrastructures (7.39/10). So, the respondents have expressed greater reliance on technical improvements that, even being more limited in their expectations for emissions reduction, are achievable with a lower level of technology challenge and in shorter terms. Remarkably, those three preferred options also attain the lowest variability, with standard deviations ranging between 1.82 and 1.86.

The respondents put the lowest reliance in aviation taxes (5.29/10), aircraft electrification (5.52/10) and emissions trading...
and compensation systems (5.73/10). The low score of taxes in aviation can be easily explained by a natural reluctance from production agents from any sector to be subject to additional taxes, as this is always perceived as having a negative impact in demand, sales and profits, as well as imposing an additional administration burden. There is not much faith either in emissions trading and compensation systems, as these are probably perceived in a similar way than taxes. The poor score of aircraft electrification (the lowest of all technology proposals) is very consistent with the views from most of the experts interviewed. It is also relevant that these technologies and policies with the lowest mean scores also hold the highest variability in responses, with standard deviations over 2.5.

Intermediate scores are attained by sustainable biofuels (6.91/10) and the new technology proposals: hydrogen powered aircraft (6.78/10), synthetic fuels (6.70/10) and radically new aircraft architectures (6.79/10).

These results are all consistent with the fact that the respondents place their expectation for a 50% aviation emissions reduction in 24 years (question V22) and that they set an expectation of a 45% emissions reduction in 2050 (question V23), as they concede a higher value to those technologies yielding more modest but certain and short-term improvements while reckoning that more significant emissions reductions will require decades.

**5.3. Analysis of the relevance of the transversal factors**

Table 4 summarizes the relevance conceded by the respondents to four transversal factors potentially impacting in the development of technology proposals and policies for aviation.

![Figure 1. Individuals concern on sustainability and assumption of personal sustainable behaviours](image-url)
emissions reduction: COVID-19 crisis, multisectoral coordination and integration, institutional and governmental support and digitalization.

Jiménez-Crisóstomo et al. (2021) discussed the relevance of some of these transversal factors for both the pre-pandemic and during COVID-19 scenarios in a descriptive way. In their analysis, they pointed out that, in 2020, the COVID crisis coincidentally concurred with the emergence of new technology proposals for aviation emissions reduction based on use of hydrogen and synthetic fuels, although they did not explicitly establish any causality between them. The respondents to the survey reckon the existence of a moderate degree of causality between COVID crisis and new technology proposals with a mean score of 5.27/10, with an important degree of scatter in their opinions (2.593 standard deviation). Needs to be noted that, even if there was not a specific question asking about this causality on the in-depth interviews questionnaire, some of the interviewees (BN) stated their existence.

The respondents assign a great importance to the multisectoral integration and coordination for the success of the technologies and policies for aviation emission reduction, scoring the highest, yet moderate, of the transversal factors (7.39/10) and with the lowest scatter (1.706 standard deviation).

Institutions and authorities’ role in promotion of technologies and policies is scored with a “bare pass” (5.11/10), with a significant scatter (standard deviation 2.47).

Digitalization is seen by the respondents as an important but not outstanding factor aviation sustainability (mean 6.87/10), with a significant scatter in results (standard deviation 2.109).

Table 3. Survey results on scoring of technology proposals and policy measures for air transport sustainability.

<table>
<thead>
<tr>
<th>Scoring of technology proposals and policy measures</th>
<th>Mean (over 10)</th>
<th>Standard Deviation</th>
</tr>
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<tbody>
<tr>
<td>V5. Hydrogen powered aircraft.</td>
<td>6.78</td>
<td>2.46</td>
</tr>
<tr>
<td>V6. Sustainable biofuels.</td>
<td>6.91</td>
<td>2.17</td>
</tr>
<tr>
<td>V7. Sustainable synthetic fuels.</td>
<td>6.70</td>
<td>2.00</td>
</tr>
<tr>
<td>V8. Aircraft electrification.</td>
<td>5.52</td>
<td>2.76</td>
</tr>
<tr>
<td>V9. Air Traffic Control and Navigation improvements</td>
<td>7.42</td>
<td>1.82</td>
</tr>
<tr>
<td>V10. More efficient infrastructures.</td>
<td>7.39</td>
<td>1.86</td>
</tr>
<tr>
<td>V11. Taxes on aviation (fuel, carbon).</td>
<td>5.29</td>
<td>2.74</td>
</tr>
<tr>
<td>V12. Emissions trading and compensation systems (such as CORSIA or EU ETS).</td>
<td>5.73</td>
<td>2.50</td>
</tr>
<tr>
<td>V13. New engine architectures.</td>
<td>7.59</td>
<td>1.83</td>
</tr>
<tr>
<td>V14. Radically new aircraft architectures.</td>
<td>6.79</td>
<td>2.29</td>
</tr>
</tbody>
</table>

Table 4. Survey results on scoring of the importance of transversal factors for air transport sustainability.

<table>
<thead>
<tr>
<th>Scoring of transversal factors</th>
<th>Mean (over 10)</th>
<th>Standard Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>V15. Digitalization will play a significant role in aviation sustainability.</td>
<td>6.87</td>
<td>2.11</td>
</tr>
<tr>
<td>V16. Authorities and institutions are doing enough to support the development, introduction and deployment of the most promising technologies/policies.</td>
<td>5.11</td>
<td>2.47</td>
</tr>
<tr>
<td>V17. The development, introduction and deployment of the most promising technologies and policies are dependent on the integration and coordination with other sectors.</td>
<td>7.39</td>
<td>1.71</td>
</tr>
<tr>
<td>V18. The COVID crisis has been substantial to the emergence and support of new technology proposals for aviation emissions reduction.</td>
<td>5.27</td>
<td>2.59</td>
</tr>
</tbody>
</table>
5.4. Analysis of future market recovery and sustainability expectations.

This block is covered by five dissimilar questions.

Question V19 aims at addressing whether there is in the aviation sector a concern about fuel availability, since it has been already proved that the concern about sustainability and emissions reductions does exist among the respondents. In mean, the respondents scored this concern with a 5.90/10, which is quite a moderate result. However, this distribution presents one of the most scattered responses, with a standard deviation of 2.6 and a mode of 8 (18%), certainly far from the mean, with 50% of the respondents scoring seven or higher, reflecting their preoccupation for a potential oil scarcity in aviation.

The expectation to achieve a 50% emissions reduction in 2050, explored in question V20, is scored with a mean of 6.44/10 with a standard deviation of 2.075. So stakeholders in the sector are fairly confident in their capability to reduce emissions in the long run, although this is not a wide spread belief.

According to the survey (question V21), the majority of aviation stakeholders trust that traffic will recover in less than four years (68.7%) with 95.3% quoting an expectation for recovery below seven years. COVID crisis is expected to be a long but conjunctural one, as the traffic continuous growth paradigm described by many authors before the pandemic and never disputed by aviation institutions and private entities (Jiménez Crisóstomo, 2020) still stands.

Responses to questions V22 about time expectations for a 50% aviation emission reduction and V23 about emission reduction expectations in 2050 have already been discussed, to conclude that the participants reckon that a significant reduction will take decades. This, combined with the expectation for a quick recovery in traffic, is perfectly consistent with the view from most of experts interviewed, that chose the scenario “optimistic 2”, as the expectation is that the traffic recovery will happen no matter that it will not go along with an emissions reduction.

6. Future research directions

As a first step the authors intend to further extend the survey sample and perform a detail statistical analysis to get deeper understanding of the potential relations or dependencies between sociodemographic variables and those describing the perceptions and expectations regarding aviation sustainability, as well as potential relations among different perception and expectation describing variables. A clear goal of the survey expansion will be to collect a wider base of international respondents, as well as more respondents from the energy and tourism sectors.

The research so far has widely covered the analysis of perceptions and motivations from air transport and aviation industries as well as academia stakeholders with regards to aviation sustainability and emissions reduction. Further research will focus on policy makers and institutional leaders as their motivations and beliefs are key for the support and development of technology proposals and policies. The authors are also considering extending the study to the general public.

7. Conclusions and recommendations

The use of a mixed methodology combining qualitative in-depth interviews with experts in two different historic moments, together with the quantitative analysis of the results of a survey run among aviation stakeholders, has proven to be a suitable method to characterise the real perceptions and expectations about aviation sustainability within the sector, and, by triangulation of both methods, to drive the following conclusions. Aviation stakeholders:
- remain confident that aviation will recover 2019 traffic levels in a moderate time frame and will continue the traffic growth track, thus the need to devote efforts to reduce emissions.
- are aware of the new technology proposals in the current aviation sustainability debate, even of those more recently arisen during 2020 (fundamentally synthetic fuels and hydrogen-based powering), although those are perceived as longer-term solutions.
- are aware of the difficulties to develop and implement new breaking technologies in aviation and thus reckon that their development and deployment so to achieve significant emissions reductions will take decades.
- do not have a homogeneous and aligned view of which technologies and/or policies have a higher potential (see the analysis of the interviews and simply mind the very high dispersion in most of the scoring questions in the query). This is a very relevant result, since it implies that it will be very difficult to get the required consensus to define committed action route maps. In this context, it is even more relevant to extend the study to institutional stake holders and policy makers.
- are reluctant to aviation taxes as a measure to reduce emissions.
- have lost (from the interviews analysis) or have low faith (from the survey results) in pure aircraft electrification potential for emissions reduction.
- value the new engine architectures as the most practical way to achieve emissions reductions, even with a contained scope.
- reckon the difficulty and the need for long term inter sectorial coordination for progressing in the development and deployment of adequate technologies and policies.
- identify digitalization as a valuable tool supporting aviation path to sustainability, but not of utmost importance.
- do not know much and perceive a limited value in emissions compensation and trading systems.

In this context, the following recommendations apply:

- the existing consensus on new engine architectures potential for emissions reduction should be levered at government, institutional and industry levels to achieve tangible emission reductions in the mid-term.
- bigger efforts should be done by the responsible institutions (i.e., ICAO for CORSIA and EU for EU ETS) to explain to the sector in particular and to the society in general the mechanisms and benefits of the compensation and trading system, as aviation will necessarily need to rely on them for decades to achieve a more significant reduction of net emissions.
- all technology proposals currently under debate should be further explored to understand scientifically their viability and real ranges of application. Again, this effort needs to be supported by government, institutional and industry stake holders.
- social expectations on aviation sustainability should be managed by the sector in a realistic manner, stressing its social and economic benefits, while humbly reckoning the difficulties to minimize its environmental effects despite the enormous efforts in place. Scenario “optimistic 2” is the most likely, and both the sector and the society need to feel comfortable with it.

ACKNOWLEDGEMENTS

We are extremely thankful to the experts that have concurred with being “in depth interviewed”, not once, but twice in a three to four year timespan. We sincerely appreciate their effort and disposition as well as their sincerity by offering their own personal views independently from corporate or sectorial communication streams.

Also, many thanks to all the participants in the survey and to those that helped to spread it in their professional networks.
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APPENDIX 1

Interview guide supporting the semi-structured interviews

- The measures currently proposed by the aviation industry aiming at improving its energy efficiency, are they enough to compensate the energy consumption derived from the expected traffic growth?
- Which aviation energy efficiency improvement measures have a higher potential, and which are at the lower end?
- Do you believe that change in aviation energy paradigm is possible in the mid-term?
- What is your opinion about biofuels? What is their potential for aviation?
- What is your opinion about synthetic fuels? What is their potential for aviation?
- Do you believe that utilization of alternative energies is more difficult for aviation than for other sectors?
- Do you believe that digitalization will be a key factor in aviation sustainability?
- Which of the following potential future scenarios you believe is more likely?
  • Optimistic 1: aviation is capable of developing technologies that are capable of making traffic growth compatible with limitations in the utilization of fossil fuels.
  • Optimistic 2: aviation benefits from progress in alternative energies use in other sectors, releasing the pressure on fossil fuels use and thus postponing any potential crisis, keeping them available for aviation, allowing for aviation to further evolve in longer term technologies.
  • Intermediate: reduced fossil fuels availability impacts on fuel costs and thus in air ticket prices, causing an important attrition in air transport demand, partially deviated to alternative transportation modes and partially compensated by changes in traveller behaviour (particularly in tourists as having a higher sensitivity to prices).
  • Pessimistic 1: deep crisis in air transport, significantly worse than in any other sector.
  • Pessimistic 2: global recession.
- In case of an air transport crisis scenario, do you believe that it would be most likely caused by energy scarcity or environmental reasons?
- What is your opinion regarding emissions trading and compensation schemes in aviation?
- How will future air transport recover in the wake of COVID-19?
- Do you believe that the “flight shame” movement may have a significant impact in air transport demand and business models?
APPENDIX 2

Questionnaire supporting the survey

Questionnaire on sustainability in air transport

Questions on the topic

Our team from the Universidad Autónoma de Madrid is performing a research in air transport sustainability. We are genuinely interested in understanding the expectations and beliefs from stake holders in the aviation, energy and tourism sectors (as well as academics from any of those fields) regarding air transport emissions reduction.

With that purpose, we would appreciate if you could support our research by taking this short survey. It will only take 10 to 12 minutes.

If you find it interesting, we will also highly appreciate if you could help us by forwarding the survey to your colleagues and acquaintances.

No need to mention that all the data are anonymous and confidential and will be statistically integrated for publication, guaranteeing individual surveys secrecy.

Thank you in advance for your invaluable support.

1. Please rate from 0 (minimum) to 10 (maximum) your personal degree of

   0  1  2  3  4  5  6  7  8  9  10

1. concern about sustainability - in general.
   ○ ○ ○ ○ ○ ○ ○ ○ ○

2. concern about aviation and tourism sustainability - in particular.
   ○ ○ ○ ○ ○ ○ ○ ○ ○

3. assumption of personal sustainable behaviours - in general.
   ○ ○ ○ ○ ○ ○ ○ ○ ○
4. assumption of personal sustainable behaviours when travelling.

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2. Which technologies/policies are most promising to achieve a significant reduction of aviation emissions reduction by 2050? Please rate from 0 (minimum) to 10 (maximum)

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5. Hydrogen powered aircraft.


7. Sustainable synthetic fuels.

8. Aircraft electrification.


10. More efficient infrastructures.

11. Taxes on aviation (fuel, carbon).

12. Emissions trading and compensation systems (such as CORSIA or EU ETS).

13. New engine architectures.


3. What are the most relevant transversal factors enhancing aviation emissions reduction? Please rate from 0 (minimum) to 10 (maximum) your degree of belief that
15. Digitalization will play a significant role in aviation sustainability.

16. Authorities and institutions are doing enough to support the development, introduction and deployment of the most promising technologies/policies.

17. The development, introduction and deployment of the most promising technologies and policies are dependent on the integration and coordination with other sectors.

4. Please rate from 0 (minimum) to 10 (maximum) your degree of belief that

18. The COVID crisis has been substantial to the emergence and support of new technology proposals for aviation emissions reduction. 

19. Aviation could suffer of an eventual shortage of oil resources up to 2050.
20. ¿Qué número crees que se volverá sostenible (reducción significativa de emisiones, digamos alrededor de 50% o más) en 2050?

5. ¿Cuánto tiempo crees que tomará el recupero post-COVID en vuelos a los niveles de 2019?

- 1. Menos de 2 años.
- 2. Entre 2 y 4 años.
- 3. Entre 5 y 7 años.
- 4. Entre 8 y 9 años.
- 5. Más de 9 años.

6. ¿Cuánto tiempo crees que llevará para que esos tecnologías y políticas tengan un impacto significativo en la reducción de emisiones (digamos 50% con respecto a los niveles de 2019)? Indica un número de años.

7. ¿Cuál es una expectativa razonable para la reducción de emisiones en el transporte aéreo en 2050 (con respecto a los niveles de 2019)? Indica un porcentaje de reducción (de 0% a 100%).