



ANTONIN GAVEAU

# **Travelling without carbon emission: is the aeronautics industry ready ?**

DEGREE PROGRAMME IN INTERNATIONAL BUSINESS  
2021

Author(s) Gaveau Antonin	Type of Publication Bachelor's thesis	Date June 2021
	Number of pages 54	Language of publication: English
Title of publication Travelling without carbon emission: is the aeronautics industry ready ?		
Degree Programme International Business		
<p>The thesis covers the aeronautics concerns, especially the current one happening due to the Covid-19 pandemic. In this work, the main goals set up were to answer the question if it's possible to travel sustainably without carbon emission? The main research problem explained so, was to prob the opinion of passengers in order to understand their needs and meet a common point with the environmental aspect of the industry.</p> <p>Therefore, the theoretical work was divided into two parts. First, the purpose was to have a clear view of the habits and behaves of the industry across the timeline from the early stage. Then in the second part, we were more focusing on what the corona crisis had allowed for the industry to change and rebuild itself.</p> <p>This was the basis of our explanation of the survey that was conducted through a web questionnaire for 8 days of test-taking, composed of 24 questions, in which 85 respondents answered. In order to ensure the reliability of the research, a quota was imposed of 1/6 passengers traveling for business reasons and it was respected. The majority of the questions was Likert scale question to have a better view on what customer expects in a sustainable aircraft.</p> <p>At the end of the study a couple of recommendations for both of the airliners and on a smaller scale, the aircraft manufacturer. From that a general conclusion for aviation was made, gathering the answers and applying them, in order to draw what could be the future of aeronautics. This, even if these answers may subject to changes during the coming years, as the industry constantly evolves.</p>		
<p><u>Key words</u> Aviation, Aeronautics, Airbus 2035, Hydrogen, Zero emission, Flight, Sustainibility</p>		

## CONTENTS

1 INTRODUCTION.....	5
2 PROBLEM SETTING AND CONCEPTUAL FRAMEWORK .....	6
2.1 Purpose.....	6
2.2 Research Objectives and Problems .....	7
2.3 Boundaries.....	8
2.4 Conceptual framework of reference.....	9
3 THE SEVERAL STEPS ACROSS THE TIMELINE OF THE AERONAUTICS INDUSTRY .....	10
3.1 Preliminary stages .....	10
3.2 The first motorized flights.....	11
3.3 The inking in the territories.....	11
3.4 The World War II and Post War period (1938-58).....	12
3.5 The arsenal logic, a model that seems to become outdated .....	12
3.6 The major changes in 1970's, Europeanization .....	13
3.7 Consequences of an integrated market.....	15
3.8 Fear of terrorism, tightening of security in the beginning of the second millennium. ....	15
3.9 2005-2011, an uncertain period with many ups and downs.....	16
4 THE CURRENT CONCERNS OF THE INDUSTRY, WHICH FACTORS CAN BE UPGRADED? .....	18
4.1 The double objectives: overcome Covid-19 and focus on the ecological transition.....	18
4.2 The three possible axes to look at, for having a green aviation .....	19
4.2.1 The carbon compensation .....	19
4.2.2 The optimization techniques.....	20
4.2.3 The innovations .....	23
5 METHODOLOGY OF THE RESEARCH.....	26
5.1 Type of Research.....	26
5.1.1 Research Design .....	27
5.1.2 Research Strategy .....	28
5.2 Justification of each question of the survey .....	29
6 RESEARCH FINDINGS .....	32
6.1 Reliability of the research .....	32
6.2 Analysis of the data.....	33
7 RECOMMENDATIONS .....	37
8 CONCLUSION & SUMMARY .....	38

9 LAST WORDS .....	39
10 BIBLIOGRAPHY .....	41
APPENDICES	

## 1 INTRODUCTION

Flying, a dream of human-being since the early stages of civilization.

From the first flight of the Wright brothers in 1903, the aeronautics industry has faced a lot of changes, leading the world to a globalized one, with the increasing number of aircraft until nowadays. Across these times, several strategies and logic had succeeded one another in conquest the market and beat multiple crises. The significance of travel means, and communication modes has grown exponentially, with the great possibility to cross oceans in less than half a day. We know that currently, every single country in the world has at least one flight connection with the rest of the world.

Historically, the aviation industry owes its fast evolution to the two World Wars, which have suddenly stimulated the development of technical performances of aircraft.

After World War II, trading by plane was seriously considered and for that, the International Air Transport Association (IATA) was established to define the rules of commercial exchanges. The 1950's, were the starting point of the second lucrative purpose of the sector, commercial aviation. This launch continued to expand progressively until the 1970's, when the market had reached a high level of traffic. At that time, the demand for passenger travel increased greatly around the world, and a larger scale of airline companies appeared. These numerous entering actors obliged IATA to come into this segment and implanted some deregulations for the commercial flights with passengers. These times were also the years of the first major crisis in history, the petrol shock. It has been, on the other hand, the high time of huge-cost project launches such as mythical Concorde, that was at the same time, a revolution in terms of speed, and a disaster regarding the environment. Next, the 80's and 90's were a period of low cost and economies of scale oriented. The beginning of years 2000's was tricky for the industry, with the Twin towers attack and environmental issues. In sum, it has accentuated the laws regarding the security control on the airport. In 2008, the Subprime Crisis had also a huge impact on the aeronautics business. To overcome

it the industry has redefined new economic models within their operational practices, and long-term strategies.

Currently, with the recent pandemic of Covid-19, the airlines suffer much from the lack of travelers. But as always, this makes the time ready to consider new perspectives, with as a major goal, green aviation. In that sense, Airbus is implementing a lead to create a new aircraft without carbon emission for 2035.

This thesis will handle first, the major assets of the industry from the first flights to the 2000's across a timeline. And on the second part, we will have an accurate view of what can be the parameters that we can modify to achieve a clean aircraft, followed by an explanation of the future trends of the industry. This will be documented with books and two recent interviews, one from Airbus and the other from Safran, a company that deals with aircraft propulsion engines.

## 2 PROBLEM SETTING AND CONCEPTUAL FRAMEWORK

### 2.1 Purpose

The thesis is written in order to explore many different ways of having as clean aircraft as possible to reduce carbon emission, as we know that flights are one of the main reasons for global warming. The idea comes from a recent Airbus article (Airbus Group, 2020) that illustrates the three main options intended for the hydrogen, zero-emission aircraft for 2035.

To ensure a good quality of research, this study will be conducted in both desk and field research.

The Desk research will include the typical aspects of aeronautics business. Then, the Field research will be conducted by a survey, to prob the opinion of passengers that take the plane at least twice a year (return trip). So, the conclusions will be drawn based on the mix of these research. To put it in a nutshell, the results will contain the

analysis of the survey's answers, in strict correlation with the technical possibilities that the industry is able to fulfill. Afterward, it will be facilitated to measure the potential attractiveness of customers to a specific type of neutral emission plane.

## 2.2 Research Objectives and Problems

The concrete objective of the thesis is so, to evaluate the potential attraction of travelers that want to fly without carbon emission even in a long-haul airplane. Find the kind of aircraft, its specificities to reach the expectations and find a good deal between user comfort and sustainability. By the same token, it will allow us to understand the greatest changes of last years due to the consecutive crisis.

The main research problem of this thesis will be to ask the opinion of aircraft passengers about the main changes that are to be considered. In other words, we can ask the research question: What are the main aspects that passengers expect from a new clean aircraft?

Directly from this problem, we can highlight some aspect that can be our sub-problems to answers:

- What do they need in terms of the cabin space?
- What did they expect in terms of airplane shape?
- Should they keep the same type of plan in terms of capacity and enlarge the space inside the plane?
- What are the main elements to focus on, in relation to the customer's point of view?
- What factors provide the real added value?
- Are the business passengers more aware of their carbon footprint than the economy class passengers? Or the contrary.
- How much the prices can be inflated to face out the additional cost of the new production of the industry?
- Are passengers ready to do more stopovers for the same distance trip to restock the plane in dihydrogen?

Thus, from this, it results in some sub-problems not directly related to the plane but, which any way, have to be answered:

- Should they create a large number of airports which are able to transport fewer passengers but in more location?
- Do the airports have to adapt their sizes/infrastructures regarding the type of plane which will stay and commute by the airport?
- Before boarding what do passengers have to know about the eventual modification of luggage capacity?
- Is the constraint of security still suitable due to the changes? Or they need to be adapted?

### 2.3 Boundaries

The study takes into consideration the general subsets of a plane and will not detail too much the components. In fact, only the relevant parts that can change the pollution aspect will be taken into consideration. Especially because the aircraft is composed of several subsets, that themselves have a huge variety of components. And that can make the interpretation of the results a lot more complex. Then, it will mainly focus on the European Market which is more exploited, and the main parts of the turnover of Airbus Commercial Aircraft. Whereas the US and China markets have complete and significant differences in terms of strategy compared to the European ones. That's why it will be evicted from the study. However, sometimes in the historical and first part, the important decisions, or events that happened in the US or all around the world can be considered for the explanation of the purpose. Moreover, the strategy for Airbus that is set up in America is not evaluated in the same criteria. For example, the airline companies are looking for more space due to the difference of bigger people height and weight compared to European. At last, it will be easier to compare the three, short, middle, long- haul types of aircraft.

In sum, this study will mainly take into consideration the customer point of view to see its attractiveness. It means that the next step is for the industry, to see if customer's requirements are achievable or not. Finally, by commercial aircraft, it means that only takes care of airliner planes which are built for the transportation of passengers or freight, not the military ones or space rocket at all.

## 2.4 Conceptual framework of reference

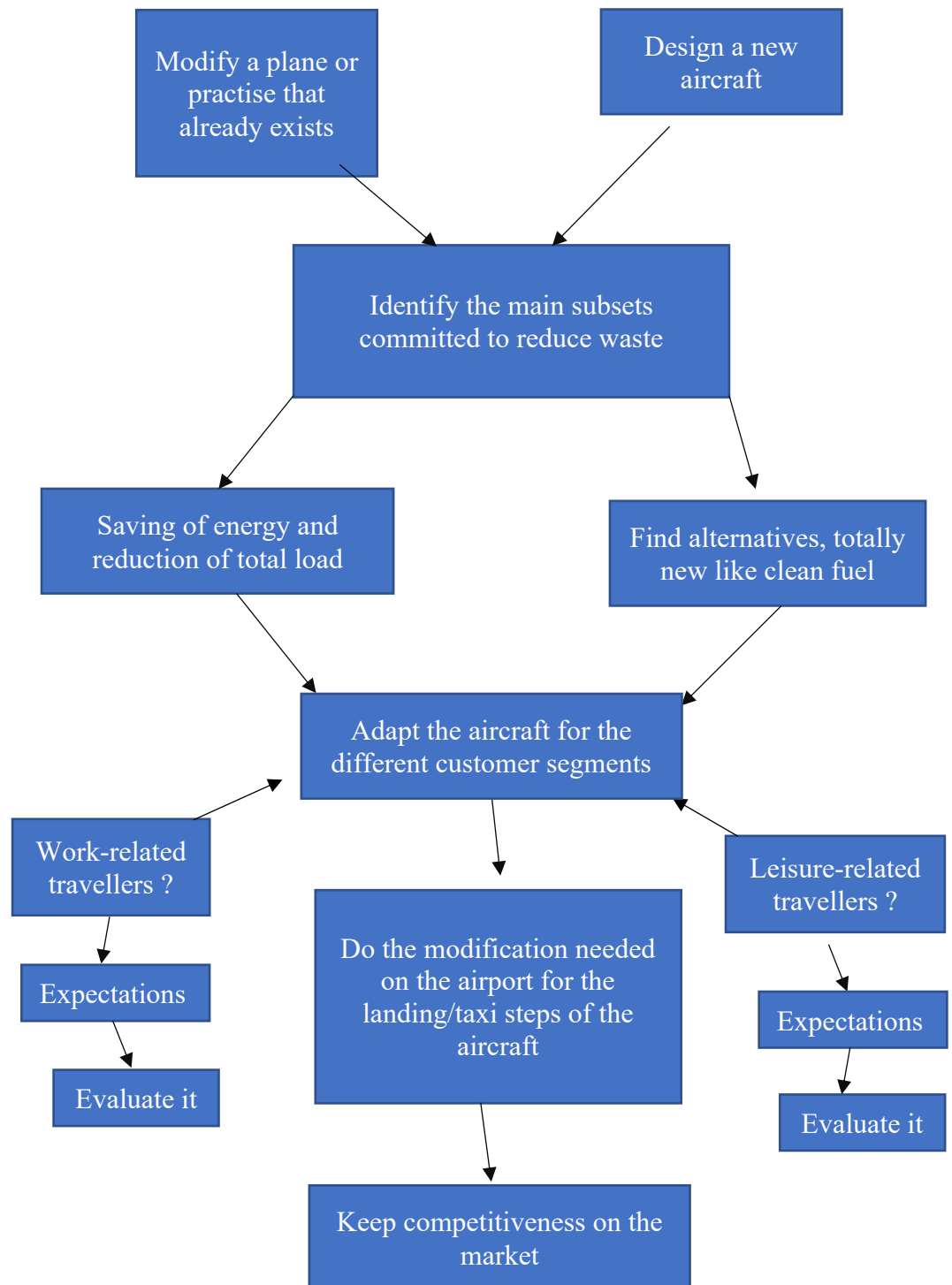


Figure 1. Conceptual framework of reference: Aircraft Dilemma for neutral emission (Gaveau, 2021)

This graph is summarizing the 2 main powerful leverage axes in order to reduce the global emission and so, highlight the dilemma that the aeronautics industry faces.

### 3 THE SEVERAL STEPS ACROSS THE TIMELINE OF THE AERONAUTICS INDUSTRY

#### 3.1 Preliminary stages

The first signs that show the existence of flying machine conception plans get back from the end of the 15-century realized by Leonardo da Vinci. (LeonardodaVinci.net, 2021) At that time, this interdisciplinary person already designed four types of attempt machines able to fly. The first one with the current idea of a helicopter system, the second was more like a sled driven by wind, then, a bat-based model, and the last one with two independent wings close to those of a bird. Unfortunately, these projects were never fulfilled. After that, the next step was more relevant and guide as a flagship, the future of aviation thanks to the aerostats. This category of aircraft is totally different from the aerodyne that we know today, as it uses only some mechanical forces to run and not any engine power. Briefly, the Montgolfier brothers launched in France in 1783 (Charente Mongolfières, 2021), the first balloon in the air, and then, it was entitled to transport humans. Later on, in 1884, the Zeppelin (Rakotondrabe, 2018) was a bigger structure with a rudder, very useful in the transportation of cargo, shipments and also environmental-friendly until at least the beginning of the Inter-war.

### 3.2 The first motorized flights

Officially, it is recognized that the first flight of an aircraft with an engine, heavier than air, was made by the Wright brothers in 1903. However, there are some indications that show the Eole take-off (French Government), of Clement Ader, six years before, with an aircraft similar, but more modern, to the plans of the Leonardo da Vinci's bat-aircraft. Then the period until 1914, focused mainly on some adjustment trials, to correct the first mistakes and improve the efficiency of the new element. These were also to establish some records as an illustration of Rolland Garros with his crossing of the Mediterranean Sea (Pigaillem, 2014).

### 3.3 The inking in the territories

During the First World War, a lot of places all around Europe were destroyed (Gourdin, 2015, pp. 2-6). As a result, it was time to develop some specific air routes to move quickly by plane. In addition, it was suitable as the major European countries had a lot of colonies around the world, for example, France with Africa or the Commonwealth in Oceania. Nevertheless, that was mainly for military purposes but also postal ones, because the capacity of monoplane aircraft, was not sufficient to welcome a large number of passengers, in order to be profitable. The consequences were a high concentration of government in technical means, such as runways at some strategic places, airports, aeroclubs, and so on. And contrary to America, the European model was relying more on public companies than the development of private leaders, to act as regular lanes on the domestic market. Due to the crossing of Atlantic Ocean of Charles Lindberg from US to France (Pigaillem, 2014), the American market start to draw some route to join the two continents. Whereas to Great Britain that trying later to find some way to go in US the North, with Canada and Greenland as some intermediary points. In sum, a competition started to grow internationally with a small delay.

### 3.4 The World War II and Post War period (1938-58)

During World War Two the industry totally stopped their improvements on civil or commercial aircraft and reached only a level of training sufficiency for countering the opponent. (Marcel, 2013) At the end of the War, as America strongly helped the Allies to win the war, the Convention of IATA was signed by forty-two countries to define rules between each member for trade and exchange matters. (Gourdin, 2015, pp. 6-7) As a consequence of all the military equipment engaged during the war, the surplus was rehabbed for civilian aircraft usage, in order to give better opportunities by the increasement of travels. On the other hand, they still kept a reserve capacity of military aircraft in case of Defense purposes. It was the starting point of the arsenal logic that the industry will keep more or less until the 1970's.

### 3.5 The arsenal logic, a model that seems to become outdated

This term mainly appears in the recent period (Frigant, Kechidi, & Talbot, 2006, pp. 36-39), as we saw a significant difference of strategy from the State regarding the aeronautics industry at each step, from production to sales.

The idea of an arsenal logic is first of all related to three simultaneous positions of the State, which are financier, shareholder and customer but also, to have only an oligopolistic market with strong national champions at the expense of the SME's. Indeed, the SME had no choice, be retaken or must merger to survive. In sum, the production of an aircraft is initiated by the State, it will loan the money and it will own the aircraft to the public usage of the country to take part of the personal reserve. In addition, as the SME are fewer on the market comparing to the national champions, the constructors can easily fix their own price and have a better place on the worldwide position, in order to beat the competition. Thanks to this strategy the European Market arrived to be more competitive but not enough to achieve as a single unified state such as the US. This because of the fact that each European country invested a lot in research and so arrived at a certain progress in Research and Development, but still, each

country worked on its own technological advance and couldn't benefit from the improvement of others. Sometimes it became really tricky and useless when two border countries were working on exactly the same upgrading. In reality there was no cooperation, and that has created the lack and delay regarding the USA. That's why it was the originations of EADS (Airbus Group) that started to set up in Europe. Added to the facilitation of exchange and trade between EEC (European Economic Community) members on the Roma Treaty in 1957.

If we look at the US market on the 60's, we can see that they were a high concentration from ramification to the bottom of the classical and aeronautical industry that have some applications in a harder industry, the Space Conquest (Aerospace, 2018). Indeed, America at that time was highly competing during Cold War, from a technological point view, against USSR (Soviet Union). In other words, it was the question of who will be first between the two major power of these times, to arrive in Space. Thus, it can explain why the US Market was more in a cool down period concerning aeronautics business comparing to Europe, and it explains a little bit the catching of Europe and their return back into world competition.

### 3.6 The major changes in 1970's, Europeanization

At the end of the Space Conquest, when Americans landed on the moon, a worldwide crisis on petroleum happened. It had a direct consequence on the aeronautics European market, that was going to innovation, with incredible fast aircraft such as the Concorde in Europe, which allowed human to cross the Atlantic in less than four hours. While in America, they were smoothly going back into their concentration on the development of commercial aircraft. (Gourdin, 2015, p. 8) In the next five years the demand for air travel totally exploded (c.f. Figure 2.A), as a result a lot of airliners were ready and expected to come into the market. Thus, each country decided to open more the market by removing the barrier to enter into the market and deregulations were settled in 1977. In other words, the logic switch from arsenal to market one, as the Demand was more powerful comparing to the State. State had only

the role of recovering the debts, as a financier. But the level of Demand was the only factor that fix the price.

EADS is a great representation of that market logic. Each single State of European Union has its own position and high level of specialization in a certain production area. It was highly avoiding the duplicate tasks between member countries.

At that time, it was so called the aeronautics Economical Interest Groupe. (aEIG)



Figure 2. EADS, in the 80's, a European cluster (Nouveau, 2017)

As we can see in this scheme, the European cluster of aeronautics is a huge complex organized in different competitive divisions which separately focus on one subset of the plane. For example, Germany had the role to produce the front and back fuselage, while the United Kingdom was dedicated to sails and Spain for rear tip. Altogether they were transported to France, in Saint-Nazaire with ship transportation, to add the central unit and the cockpit. Altogether were assembled in the Toulouse area, on the final assembly center of Blagnac. This great consortium of multi-national cooperation is still valid today, however a little bit modified due to the last news concerning Brexit and some structural change coming from Airbus's behalf.

### 3.7 Consequences of an integrated market

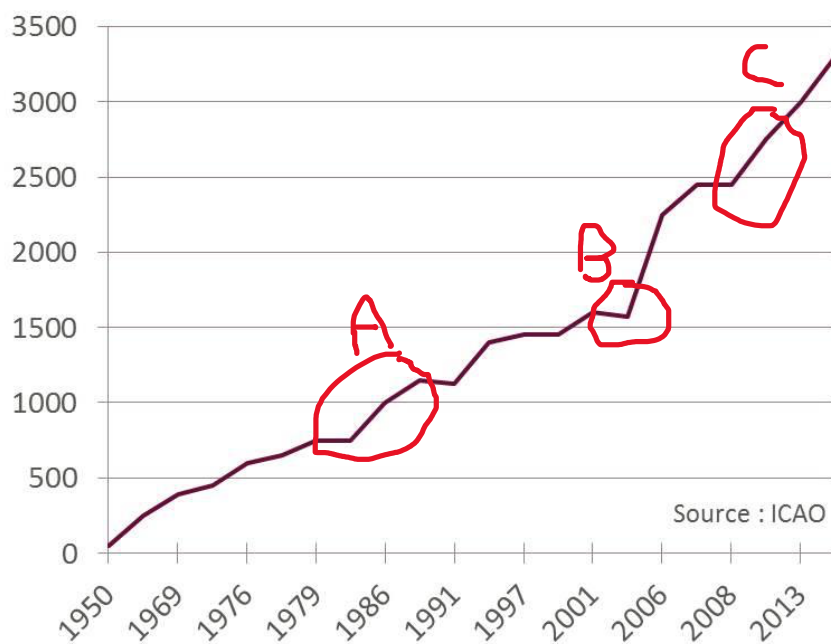
Airbus had focused more its strategy on having simple planes (Frigant, Kechidi, & Talbot, 2006, pp. 47-49), with standardized tools and technologies on it that can be interchangeable from one family of aircraft to another. It was a great idea as it implemented some economies of scale and so, gained on the other hand, effectiveness to respond quickly to the customer Demand. These planes were totally adequate regarding the expectations of customer in terms of competitive price and delivery times that highly differentiate them from the American market. In reality the American market was a little bit tidy concerning price, as their passengers were always constraint to pay all the extra things during flights and on the airport, in surplus to the price of the seat. (Gourdin, 2015, p. 8) That's one of the reasons why the European consortium caught up the American one, in terms of performance such as in market shares and turnover.

At the end of the century, only the big corporations that undertake a lot of smaller and promising companies, were continuing to grow. The rest were entitled for smaller orders as subcontractors but only in case of subsidiary provider.

### 3.8 Fear of terrorism, tightening of security in the beginning of the second millennium.

Since the terrorist attacks of the 11<sup>th</sup> September 2001 on the World Trade Center with the two Boeing 747, the deregulation laws totally ended and become very strict, as up and downstream restrictions, in order to avoid air hijacking but widely to avoid terrorism. (Gourdin, 2015, pp. 13-14) These rules and procedures were hardened on spot directly to the airport, by a control of objects transported, metal detection and so on. But also, during the pilot training session with much more psychological tests for knowing if people are possibly dangerous for general safety. As the consequence passengers were disappointed of the reduction in freedom and the fear of another terrorist attack. In sum the general transportation of passengers was reducing slowly during the next following years (Figure 2.B).

En million de passagers



### *Evolution du nombre de passagers aériens mondiaux*

Figure 3. Worldwide evolution of airline passengers from the 50's (ICAO, 2015)

The reaction from European countries was to be more unified and create even more common rules. As a consequence, in 2004, a lot of Eastern countries entered in the European Union (EU), and that was a part of the reasons given (Science Po, 2020).

#### 3.9 2005-2011, an uncertain period with many ups and downs.

In these years the fuel cost, which is around 14 % of the global operation cost of the aircraft transportation, continually grew until 2013, by multiplying the price per 4 to amount 73,5 €. (Gourdin, 2015, pp. 13-14) In 2007, there were already some clues about a possible high crisis coming in the next years, as the public debt in America was increasing each year faster than before. This can be explained as a part of the means committed during on the track of Bin Laden. But mainly for the economic bubble of the real estate area, regarding the housing demand, between 2003 to 2007. (Baily, Litan, & Johnson, 2008) Therefore, a financial crisis started to impact overseas, including Europe. People were losing money drastically, so their purchasing power

was decreasing. So, the airlines had to rethink themselves, in order to stay profitable, because having an aircraft at the shed or not full is not sufficient to cover the general expenses. And that was in short, the perfect period for the development of a new type of aviation, the low-cost companies (LCC). (Inxelo Technologies, 2020) The LCC had understood that if they wanted to have full flights, they need to provide competitive prices compared to the huge number of existing airliners. That's why they ask from their customers a very low price. Furthermore, the fact that at that time, the majority of people wanted to travel from point A to point B in their seat for a short and middle-haul travel, without having extra-service like drinks and meal. It's a kind of return back from the origins in the 70's. By minimizing operating costs, the results of this plan by the 2010's, was exceeding the expectations of the LCC, the majority of their flights were full. Thus, it has two major negative consequences on the general aviation:

The first was related to the traditional carriers, many of them went bankrupt as they wanted to keep the same services but adapting their price in order to be competitive. It was not so achievable as they still wanted to keep the same reputation, even if a lot of them try to merge to compensate the losses. The second one was more related to the brewing of passenger within the airport. Indeed, there was a high increase of clients in the air flight (Figure 2.C). In ten years, it had almost doubled.

These years were also the time when the oligopolistic market of constructors between Airbus and Boeing stopped, as Comac, a Chinese manufacturer appear in 2008 and continue to grow until now (Comac China, 2021). For the middle and short run flight, Embraer a Brazilian constructor, third worldwide is also surging into the market with competitive prices for airliners (Embraer, 2021). Or then from the Canadian view, with the aircraft specialized in commercial jets, Bombardier, fourth worldwide (Bombardier Aéronautique, 2021) .

As a final statement of this part, we can see a highlighting of the ecological considerations, as the air transport is responsible of 2 to 2,5 % of the whole carbon emission in the world. (Dumez, 2021) However, the textile industry and heavy industries or even the internet data exchanged have more weight than that. So, it is not the first source of carbon emissions, but it has to be regulated.

## 4 THE CURRENT CONCERNS OF THE INDUSTRY, WHICH FACTORS CAN BE UPGRADED?

### 4.1 The double objectives: overcome Covid-19 and focus on the ecological transition

It is important to understand that the aeronautics industry has, from the early stages, tried to rethink and rebuilt itself each time that it faced a crisis by innovative models. Indeed, in 2020, the corona-crisis has been caused a lot of losses for the aeronautics concerns, that is why the industry is challenging a double objective. These are to overcome the crisis by believing on the green aviation in an ecological transition. It had never happened by the past that only 20 % of the whole aircrafts, on average, were flying and the rest was remained on the tarmac. (Ministère de la Transition Écologique, 2021) That was really tricky as the operating costs of aircraft maintenance still need to be charged. It was the first time that the turnover of the sector has totally plummeted for around 30 % equivalent to around 50 billion euros of losses comparing to 2019. (Meddah, 2021) As a consequence, the SME's and first rank subcontractors were much more affected, than the rest (about five times more impacted than the MNC's). Thanks to the Airbus Space & Defense, the sector has kept some attractiveness with important orders, coming through Germany with fighter jets. (Airbus, 2021) From the labor force point of view a negative outcome of 8.000 direct employees were redundant, generally it is the highest salaries and the older employees of the company determining by a scoring of a lot of criteria. (France 3 Occitanie, 2020) As an example, on the Toulouse production site, a plan of 3.378 employees were asked to resign. This crisis will still have a great impact on the long-term view for the future and it will take time to get out of it. That's why, once again Airbus affirms its willingness to overcome this hard crisis and switch to a greener aviation. (Klaas, 2021) In sum, it is easier than before to focus on more adaptable production lines, as the part-time employment has required a lot of significant changes on the working manner. In that sense the green focus seems to be a great opportunity to leave the crisis. By focusing on new technologies and other environmental protection, they will be more able to gain market share, as they innovate a lot, and that can have an impact on

worldwide competitiveness. Especially as the European consumer is more and more aware of the direct consequences of global warming.

#### 4.2 The three possible axes to look at, for having a green aviation

As their first role, aviation has to understand the current needs of their population and still continue to run. In that sense, it is really important to adapt itself in relation to the new concerns, because travelling by plane is connecting people, it's the networking that encourages people to live in peace.

If we bring back and compare the ratio of fuel consumption by passenger it is almost equal to  $3L.100\text{ km}^{-1}$ , comparing to the car consumption which is on average around  $5L.100\text{ km}^{-1}$ . If we look directly to the rejection, the carbon emission for around 100 passengers among 100 km is  $9\text{kgCO}_2\text{e}$  equivalent to  $285\text{gCO}_2\text{e}$  per passenger for 100 km. Comparing to car it is almost the double. (Ayoun, 2021) That's not enough energy saving, as the plane usually runs through more than 1000 km while the car does only 100 km.

The aeronautics business has at least three major parameters to deal with, for achieving a clean aviation without carbon emission. All the information below will mainly be coming from three current video sources : (Tyltelman, 2020) (Dumont, 2021) and (Guénon, 2021).

##### 4.2.1 The carbon compensation

The first one is well known from the large audience until now, especially in the textile business, but still not often taken into consideration, it's the carbon compensation. (Tenoux, 2021) The principle is quite basic, people are paying an additional cost to compensate the pollution that they will cause during their trip. Most of the time the money earned by this way, is retransferred directly to a labor force, around the world, that will plant new trees, which are theoretically supposed to absorb the  $\text{CO}_2$  rejected in the atmosphere by the passenger. However, the complex limit of

this system is now more and more questioned as this surplus cost, is not directly included in the price of the flight. The person who buys the ticket can decide to pay it as a donation, but it is not mandatory at all. As a consequence, it is really rare that people pay it. So, the piece of advice can be to include it directly in the price while purchase, as named as an ecological tax for transition. It can be suitable as currently about 29 % of the airplane ticket price are charges and taxes. (Louis & Tanca, 2019) We guess that the State can require from the airlines to oblige this carbon compensation. An idea should be that State provides bonus for airlines that is buying a new plane, as generally they find their good deals have new technologies that can compensate the higher fuel consumption of older models. It can for example provide a scrapping premium such as in cars to recycle the old airplanes. And on the other hand, discourage companies that are willing to keep their old fashioned planes. We will see it later, but it's the most probable planned way while we are waiting for the technological and infrastructural changes.

#### 4.2.2 The optimization techniques

The second one, is a model that is often used in a lot of manager position, the good usage of resources. By this, it means that all the steps and aspects from up to downstream, or even before during and after the flight have to be considered. For example, we can think about the infrastructure available within the airport, it can be driven by a complex of renewable energies around the airport. Believe about wind energies, solar one or then generally optimizing the resources by the management of waste, low consumption facilities and machines and so much more. The airlines are looking for any gain of weight, through seats reduction, or even some grams in relation to the food distributed, it always creates economies of scale and petrol saving. Then, we can imagine the usage of an enterprise resource planning (ERP) adapted to the needs of aviation, to have a better management of capacities, flux, and be more flowing, in order to have an efficient treatment of passenger needs. In sum having a sufficient supply chain management. (Godenne, 2019) Each of these optimizations can encourage and stimulate the reduction of carbon footprint.

Additionally, the air routes can be also optimized in relation with the development of well performed software and big data that are able to do a lot of calculations to reduce the global pollution and unnecessary stops. As an example, we can note that now, an aircraft coming from Los Angeles to Tokyo will take a parabolic road, by travelling through Canada and the North Pole, instead of following the same latitude. It can be explained by the flatter shape of Earth, but without these accurate calculations, it is impossible to say if finding another route will save some fuel and so reduce the emission. In other words, it reduces drastically the unnecessary movement of airplanes and gain effectiveness for the airliner. On the same subject the idea of traveling near some GPS tags becomes outdated as the Artificial Intelligence (AI) is able to calculate the best trajectory, especially in relation to the SESAR program that aims at better driving with more connectivity, by installing the Wi-Fi on the top of the cockpit to track the plane. (Tyltelman, 2020) In sum it can reduce by 6 % the operational emission during the flight. Also, the big data combining to AI are helping a lot to reduce the rush and waiting time at the airport, for example by leading the arrival successions of planes during the landing. Moreover, the big data can have a lot of application through the weather forecasting, by defining the best speed to save fuel or avoiding going into turbulence area. This can be held by a great transmission of the data between the aircraft and the following one in the corridor. An amount of 120kgCO<sub>2</sub> can be saved like that. With the same usage of the AI, we can calculate some scale between each aircraft, in order for the following to take the advantage of suction that is created by the movement of an airplane during the flight.

After that if we look more particularly at the aircraft pollution, we can highlight many fields of actions possible. As an illustration, we can avoid the usage of the Auxiliary Power Unit (APU) later than before, by starting in the last seconds before going into the taxi way. It can save some energy because sometimes it is used even if some passengers are not seated and ready to take off. Then, when the plane is on the runway, we can stop to run with both main engines, only one is sufficient to move smoothly to the right track. Nevertheless, it's a little bit complicated, because the main engines require a heating time to provide maximum power before take-off. Three minutes of working is enough for the engines to be prepared, so we can save energy from two to seven minutes for the far runways. Then during the landing stage, the type of descent can have a significant impact on the fuel consumption. Traditionally the

pilot is having a stepwise descent, the major problem of this one is that the aircraft needs to turn a new time on the engine during the stabilization stage of the level, and then it reduces for rebegin in the next one. This creates a lack of saving as proceeding by a continuous descent the finesse of the wing is sufficient to lead and decrease the speed of the plane without any major engine, just the APU in idle mode, to the airport. The same operation of optimization fuel while running on the runway can be applied after the landing. Furthermore, the objective of an aircraft can be to directly be connected to the electricity network of the airport since it leaves the taxiway, instead of using the thermal energy of the APU to provide power for electrical devices. It's a similar operation for the climatization. The estimation of energy saved can reach 3%.

Another idea more practical but harder to set up, can be to drive the aircraft with the airport tractors directly to their runway. However, it can create some longer waiting time to take off. These good practices can sometimes be driven by some start-up that has decided to develop their business in a particular optimization method. The thing that must be totally abolished is the "fuel tankering" as it has a huge environmental impact. This practice, conducted by a lot of airliners, is based on the importation of petrol where the cost of it is the cheaper.

From another perspective the constructor of first rank, Safran and others, must also do some efforts concerning their management of resources during the creation of the subsets. Also, it occurs that the final aircraft manufacturer can find a component that is useless for the general usage of the plane, as new technology not necessary need it. So, it's a good way to optimize the weight on board. Alternatively, the method that the airline can apply for, due to the pandemic is to rent the plane. Most of the time, the airliner buys it, however with the sanitary crisis has changed the situation, as the operating cost are huge. If the airliner will use the plane only once a month, it will not cost too much to pay it by usage and by the same token, avoid using it at loss. So, the environmental impact will be reasonable in function of the demand. This strategy was totally understood by the LCC as they mainly focus on this partial exploitation

### 4.2.3 The innovations

The last factors that have the more influent role and maybe the most amenable to have some changes, the technological innovation. Here the list of possibilities stated will be for sure non exhaustive as every year possible changes on plan and innovations can occur. All of these need a lot of engineer teams to set up the project.

Starting with an innovation that is already existing on some planes but has to be generalized to gain effectiveness, the winglet. Basically, a plane is composed of four forces, weight opposite to thrust and drag opposite to lift, each of them is inscribed in a direction. The winglets or sharklets are so set up at the end of each wing, in order to reduce the thrust induced. As a result, if one force decrease, the plane is kind of decreasing is weight and it needs less power to move. So, it saves kerosene due to the release of the engines. The operation, so called the retrofit, is a characteristic that is already available in another type of aircraft and that can be generalized to other in order to same 4 up to 5 % of fuel.

Now we move on the proposed ideas to reduce the fuel consumption and emissions. The main purpose is to switch from a hydraulic system through a hybrid one to an electrical one, with batteries as maybe a complement of hydrogen energy. (Dumont, 2021) But to achieve it, it has to proceed step by step, as each part of the aircraft as to be redesigned in order to welcome the new specificities. The transitional ideas are the usage of biofuel to see if this is already achievable. And if it becomes the case, the hydrogen option will be much studied. Concerning the hydrogen precisely, it is much larger than kerosene to conserve but much lighter. By the same token it improves the aerodynamic performance of the airplane by 15 %. For the electrical energy the benefits can be big as switching from hydraulic to it can reduce the weight of 500 kg however, it has to find the good trade off regarding the autonomy of the aircraft. For the biofuel the aeronautics business has engaged to not use any raw material, such as palm oil, that can compete the food market. In 2025, the idea is to transform not only frying fat but more generally tree's leaf and minerals into biofuel. These alternative fuels can decrease the consumption by more than 70%. As a result, it can lower the sulfur emission and so the condensation trails, that creates some cloud on cities. It has an impact on global warming by refreshing with the cloud creation,

that reduces the temperature increased by the running of the aircraft. But it is not related to the CO<sub>2</sub> emission.

Then believing on the earlier idea of making economies during the taxi step, we can imagine the landing gears that will be drive electronically with independent engine on it, to save fuel. (Pollet, 2021) But it is still the same problem, the engine need time of warming-up and it may increase the weight. The “ROPS” (a landing software) system will be a useful tool that can be set up for avoiding the throttle back during landing step, when planes are doing too many circles as the landing runway is full of other planes. The delta wing, that is enrolled on the project aircraft of 2035, it is the occasion to change at the same time, type of fuel and shape of the airplane, in order to see if both are possible.

One idea can be to remove the current materials used and replace these by composite materials. However, the major problem related to that is that contrary to the aluminum, copper and zinc that usually form the fuselage and the cabin of the aircraft, the composite is not so solid and resistant. In sum, it has to be protected and requires a double of total weight to support it. Afterward, changing the raw material that composes the pilot command by lighter ones or even a simple reduction of magazine (like the famous case of Delta Airlines) weight can have by economies of scale a huge impact on the carbon emission at the end of the year. Often in the industry reducing the noise of a plane is strictly linked to the pollution aspect. (Guénon, 2021) As an illustration, the augmentation of the diameter of the nacelle propellers of the engines can highly increase the dilution rate and so avoiding losses or sounds. Therefore, the fuel consumption is also reduced. However, it is always the same question of how much the weigh will increase in that case?

Now in terms of conserving the biodiversity, the engine can attract the birds during take-off and landing steps, nevertheless, the engineers of Safran have thought of a system that equally distributed the heat regarding the shape in order to avoid let birds go in the firebox. It has also an impact on nitrogen (NO<sub>x</sub>) that can be still divided by four into 2050. The innovation concerning engine can be huge. For example, focus on the high thermal yield, it is much better if the entering air is more compressed. But

the increasing of temperature in the chamber fosters the rejection of NO<sub>x</sub>, that's not so good for trail.

Moving on to the Open Rotor, which is a quite innovative concept as the engine is directly open to the air without carter. So, it results more dilution without adding weight which promises saving of 30 %. However, the noise problem can become again problematic. Thus, the conception has to be thought aeroacoustics. Working on the improvement of the engine is needed in every case, whatever is the type of fuel. As a guideline we can say that before switching totally to electrical power the industry has to find the way to hybridize the engine in a short and middle term perspective.

To put it in a nutshell, a plane that wants to be green has to focus on the following criteria, making the airplane lighter, having a better aerodynamic performance and think about new way to motorize the vehicle. The thing that is certain today, is that the industry must innovate, as only doing optimization plans and carbon compensation are not enough, due to the fact that every year the number of aircraft in the sky increase and the market grows proportionally. So, if we fix only compensations or operational changes, the Earth will not be able to fulfill the huge emission of airline traffic that also increase each year. But the innovations have always to stay in adequation with the market, to avoid having the product ready before the demand.

A good engagement that leads this industry is the ATAG one that aims to divide per two the global carbon emission caused by worldwide aviation, accordingly to its annual growth. The EU is going forward, as they want for the industry to reach in 2050 the carbon neutrality. In other words, every single CO<sub>2</sub> emitted should be compensated.

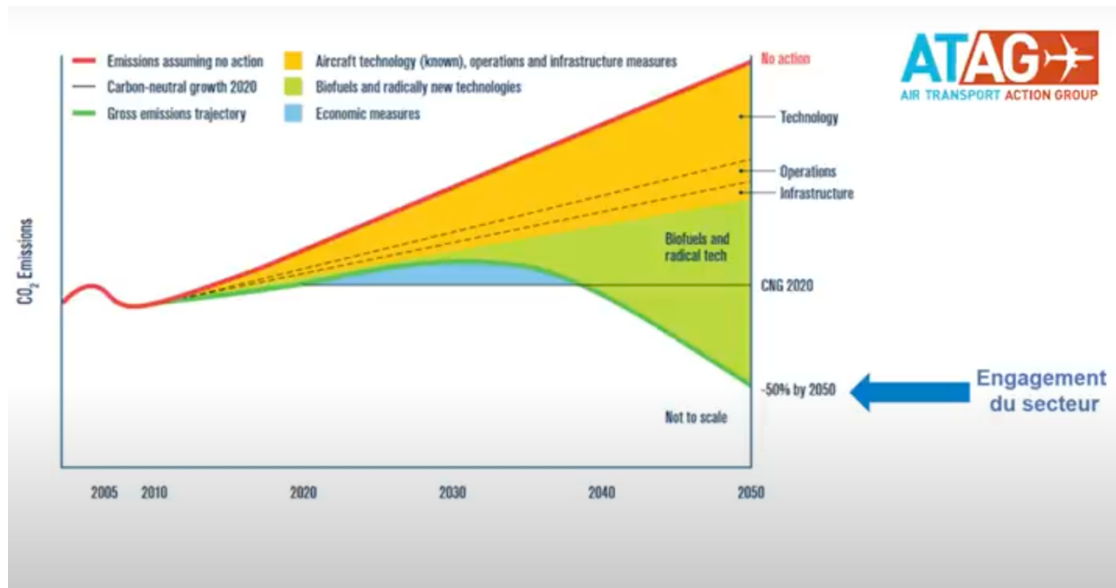


Figure 4. Projection of global emissions of aviation: Goals for 2050 (ATAG, 2020)

The following graph (Figure 4) is showing what will happen if nothing changes by 2050, and below that, the details of each stakeholder responsibility in these reductions.

Finally, if the three parameters are not enough for the reducing the global carbon footprint. The aeronautics industry has to follow the last opportunity changes. The size of airplane must be reduced and as a consequence have a huge number of airports but smaller around the world. (Sympa, 2021)

## 5 METHODOLOGY OF THE RESEARCH

### 5.1 Type of Research

In this part, a description of each possible way of research method will be explained. Based on all these possibilities we will have a clearer view of which methods we will choose to ensure leading a strong and reliable analysis. For that, we

will mainly refer to two great books of Research methods and Marketing (Churchill & Iacobucci, 2002), (Saunders, Lewis, & Thornhill, 2012) and (Kotler, 2015).

### 5.1.1 Research Design

Typically, there are three main different options in the Research Design step:

The first choice is exploratory research, which mainly focuses on answering the question what? It gives an overview of the research topic. Basically, it is really useful when we don't know too much about this area, it can especially help you to formulate some deep and more constructed problems to go further in your study. This part can be fulfilled through a couple of tools such as these that were done in the first part of the literature review. Another can be to meet some experts on the subject to have accurate data and understanding of the subjects. At last, we can also conduct a focus group with interviewees that will give you an overview of what they believe about your topic. We will personally don't use this kind of own research in that part as we already covered pretty much the topic of the literature review process. That's why we have already a quite narrow topic covered to conduct well our research process.

The second one is descriptive research, it aims to describe with more accuracy the happenings and the representation of the phenomenon, person, or situation related to the topic. Often it helps the writer to formulate precisely the research problem and highlight the hypothesis. In every case, each thing is deeply planned like from the sample to the analysis of the process. This can have several outcomes for many versatile areas. As an example, we can thank for that, describe the main characteristics of a group of people. Then, it can measure the attractiveness of the customer segment and their proportion. Finally, it is also possible to have some direct applications for forecasting any specific prediction. Afterward, the tools that can serve its purpose can be an analysis of secondary data, deep interviews, or also surveys. In our case, the questionnaire aims to sort out and measure how could be attractive our potential target of airplane travelers to new aircraft and ecological considerations. Above all, we will

see what they expect for the aircraft industry, so do a kind of summarization for the industry to let them know what they must focus on to satisfy customer demand.

The last possibility is explanatory research. This one, is mostly done for situational cases and so draws for each variable some links and highlights their interaction. Then, it is for example used to find out any casual relation between the revenues and the way to travel. From that, we can apply a lot of different methods, like case studies, historical analysis, observations, attitudes, and statistical surveys. We believe that in this kind of research we can sort out just some statistical survey but not coming from an interrelation between variables, as there is no impact for the industry to see the link between each category of customer. We just want to see if according to actual users, people are ready to have some changes during their travel to be more eco-friendly.

### 5.1.2 Research Strategy

The next step of the process is to define the right strategy that will make you easier the fulfillment of your research objectives and questions. Here it's so describing more precisely, how will be conducted our research method.

Basically, there are two main ways to lead research. Qualitative research is a method that aims to understand the deep reasons of the question "why?" and sort out words. This can be fulfilled by having an approach more open, less structured with a small number of people studied. As the aeronautics concerns are quite technical it will not be suitable to follow this kind of strategy, that's why quantitative research will be conducted. Indeed, quantitative research is better when the goal is to answer the questions "how and how many?" and focus on figures. It is more adapted to a large sample that is answering clear and already defined questions, to sort out trends and draw conclusions based on the descriptive statistics.

So, in this study, it will cover how to create the support, guide and so on. For us, the main useful thing for the survey is to define the right "wh" questions, what we really expect that the customer responds to. It's especially more relevant, as we focus mainly

on descriptive research. In this survey, we will analyze not much more than 20 questions around, with mainly multiple choices, in order to be able to collect a large amount of respondents' answers.

Later on, to select the population that will be included in the survey we understand that it is unachievable to do a totally pure random sample, and so we must select it by convenience, as we don't have access to the complete list of worldwide aircraft passengers, in order to select them randomly. That's why we will anyway try to be compliant with the representativity of our sample, by meeting the quota of 1/6 passengers traveling for business-related reasons, that are on the plane, and the rest of the majority will be leisure or other for reasons related passengers. According to Kotler and its "t Student table" to ensure the reliability of the quantitative research, the survey has to have at least 120 respondents to have a sufficient confidence interval.

We will see it with more accuracy in the next part to describe the details of every single question and reasoning about their usefulness. But the data will be collected in a Google forms questionnaire, short, with some informative data to aware the customer of the environmental impact. That's for all of these reasons, why a quantitative method is the most suitable for our research.

## 5.2 Justification of each question of the survey

In this part, we will refer to the questionnaire findable in appendix 1, which is the survey that we'll be conducted the research with. It has first to understand, that due to the fact that the researcher (Gaveau Antonin), is French, a lot of his acquaintances are French speakers. Thus, the survey will be led in both French and English, with mainly French, Belgian and Finnish respondents. Also, some others can be considered but still, they will come from the Snowball effect. That's why the first question is separating the two tracks. And with the usage of different translator software, ensures that in each language all the information given are containing the same question's content in both. For having a common result, we will merge the questions of the two-track together to have only one respondent.

Let's start with the first real question the purpose of the trip. Here we will classify the travelers for their reasons, and so from that question, we will ensure directly the quota of 1/6 people for business purposes. Then, moving on to the elimination question, in fact, we ask the respondent if he travels at least once a year for a return trip, if it's the case, then he will normally continue the survey but if not, he directly stops there. After that, we ask in which class the travelers are usually flying, thus it will allow us to see the proportion of business class passengers and premium in the survey. Later on, we start the heart of the study, with the carbon emission, in sum, we ask the respondent if he is aware of the carbon emission coming from the air traffic. If the respondent says yes, we ask him to give the figure (in percentage), in order to know if people are really knowing the right proportion. Then, in every case, they have a small explanation of the real environmental impact and comparisons to some other industries, in order to give them an idea. Further, we ask them if they would like to know the figures from the airliner for every single flight they take. Therefore, we will see in the function of the responses if the airliners must do so. Afterward, we start a couple of questions that are related to what the customer can directly have an impact on. So, from that, we will find out the right conclusions to the industry to keep on the same track as the customer expectations in their three-leverage effect. For all of these questions, we will use a Likert scale with 5 choices from "Strongly disagree to agree". Thus, for the next question, we will see if the customer is ready to pay himself this compensation carbon by donating for each flight he takes. Moreover, to accurate this question, we will in the next one asks if he believes that the industry should require this surplus cost. If the respondent check at least, "Agree", we will ask him the reasons in a free text question. In that way, we can have a deeper understanding of why he does so. Thereupon from both of these questions, we will see if it's at least, it can be considered while waiting for the industry to provide the technical and ecological advances. Next question, we will for both cases, have the question of a practice that they feel useless and outdated, in the airport or onboard. Even if there may have a low level of answer to it, it will allow us to explore some optimization techniques that the industry has not thought about until now. Moving on, the service of food on board, we will check here if the customer is ready to receive less package that creates waste during their meal. Here we will let understand the importance of the economies of scale in aeronautics to reduce significantly at a worldwide scale, the carbon emission

with a concrete example that they can set up themselves. Then, the two following questions are related to technological improvements, to let us know if customers are able to spend more time on the ground in the aircraft, in order to save fuel and also to see if a smaller but cleaner aircraft, with electrical energy, can fit them. The two questions coming next are more related to the customer habits and what he rather prefers. The first one is concerning the optimization of air routes, in order to know if the customer is ready to have more direct flights, even if he pays more than doing a lot of unnecessary routes with many layovers. The second is more related to the size of the airport, indeed if the industry is not able to have enough space to stock clean energy, they need to have fewer seats on board. That's the reason for the asking of customer flexibility to travel through airports that serve fewer destinations. Afterward, we present the three types of aircraft forecasting by Airbus to be conducted by hydrogen, we will then see which one seems to be more suitable for them separately for the long run, and then for both short and middle run trips. In relation to the pictures, we will ask the customer to see if he agrees to have less space on board but also on another type of aircraft, be able to travel with more noise (due to the open rotor). From that, we will see if the current proposal of the industry seems suitable for them or not. Finally, for the last Likert scale questions, we will see if the customer is generally able to do more stopover (so without transfer but just waiting onboard), in case that the industry doesn't find any solution to the high and fast consumption of hydrogen liquid. In the end, the last questions are descriptive with socio-demographic questions, such as the socio-professional category according to the French law but adapted a little bit to European standard ones. And at last, we will ask the age of the person by a category of age and the sex. These three questions will be there to see if there are any possible biases in our study, for example, if a social category is often more represented.

As a consequence, when the 8 days of test-taking will be done, we will use the SPSS software to analyze the descriptive statistic like average, standard deviation, extent and so on but for the rest of chain variables it will be only the frequencies of the answers. Thus, to give our conclusions about the potential customer needs from the industry.

## 6 RESEARCH FINDINGS

### 6.1 Reliability of the research

To ensure a good validity of the survey and avoid any methodical bias, we have to check one by one the descriptive questions that concerns directly the population studied. And if there is any potential one, we should measure how can it affect our study.

At the end of the 8 days of taking the survey, the level of respondents had not reached the number of 120 people, to ensure the reliability seen on the “t Student” table (Kotler, 2015). However, with 85 respondents it seems that the level for a unilateral analysis of quantitative research at 95 % of trust interval, is only of increasing the scope of it by 0,018 (increasing it from 1.645 to 1.663 for both sides). So, it will not affect so much the results of the survey.

One first possible bias could be that there were much more French speakers respondents than Finnish or English-speaking people. However, in every case, as the sample is selected by convenience, it's even impossible to ask a representative portion of each European country. So, it will affect the study anyway, but from the lowest impact possible.

Then the quota of 1/6 travelers for Business reasons was reached with 16 respondents for this reason. Therefore, it corresponds to around 18 %, which close to the 16,66 % imposed. So, the analysis will correspond to the plane's usual configuration. Just to note that two people were traveling for both reasons, that why they were split into the 2 different categories one for leisure and the other for work. (c.f. Appendix 2, graph 1)

From the traveling class, we can say that we don't have too many Business Class passengers that have answered our survey, only 4. That can be biased on the study as if we refer to the general configuration of place there is at least 10 Business class seat, even in the short-run flight. Then we have 10 Premium Economy passengers

equivalent to 2/17 people that take the plane, this is quite proportional to the proportion of the population in accordance with the plane layout. (c.f. Appendix 2, graph 2)

Thereafter, for the socio-professional category, we can pretty much say that our sample reflects quite well the repartition of passengers with the most represented category, the higher intellectual profession (those who usually earn the most so can afford air travel easily) with 1/3 of the total respondents. Then the students, middle professions (teachers, nurses...) and the rest of employee weigh from 15% up to 20 %, that takes the plane but not so often. And the less usual air customer like retired, agriculture and craft men/business owner are less 10 % and it's for the very rare that most of them take the plane because they have to stay near their activities or don't want to move anymore. In sum, we can say that naturally, the sample is well distributed according to the general and usual passengers of aircraft. So, we cannot consider any bias from that point. (c.f. Appendix 2, graph 3)

Additionally, concerning the variety of age groups, it is also well distributed, with a 5% of interval approximately between each class group. We are at around 20% for every single category until 56, and after in reality when people become older (close to retired) they usually stop moving regularly. The 46-55 and 26-35 years old are the most represent but it stays on the same scale as the rest. That's one of the reasons why this sample cannot influence the study. (c.f. Appendix 2, graph 4)

Finally, the gender is pretty equal at 6,5% near, ~55% for women, and pretty equal, and we don't have access to the general statistics of the traveler's gender. We know that in general life that there is a little bit more women in the world than men. That's why we can guess that this variable will not have a strong effect on our effect in the case that it is one. (c.f. Appendix 2, graph 5)

## 6.2 Analysis of the data

In this part, we will go through each question of the survey, to search if we can sort out any research findings from the answers, and then we'll precisely guide in the recommendation part what the industry must focus on according to the passengers.

First, for the question concerning the awareness of passengers, we can say that more than half (~55%) of them don't know how much emission are really enrolled by the aeronautics industry. (c.f. Appendix 2, graph 6). Furthermore, if we take into consideration the rest that believes in being aware of the carbon emission we can first, see quite scoped as the extent start from 2 until 90 % (very huge). It is also reflecting in the means and standard deviation are respectively of 21,74 % and 24,72 %. In sum people are usually very confused about the question, they often overvalue, from mainly ten times, the share of aviation in global emission and so it's like for them they see the industry as guilty and consider their liability instead of only a part of it. Only the people that have a strict relation with the industry (air workers, people interested in aviation...) are close to the right figure of 2,5/3%. (C.f. Appendix 2, graph 7). Later on, 74,1 % of the respondents want to be informed of their own footprint during their travel. So, airliners will have to focus more on this ax in order to fulfill the demand requirements.

Then, we will start the Likert Scale question. To start with we can highlight that people don't have any positive or negative opinions about their wish to give a donation as the majority is close to "Neither Agree nor Disagree" and the standard deviation is close to 1 scale up and down (Agree and Disagree). Moreover, it's in accordance with the fact of the answers, when they ask if this cost should become mandatory until the innovation of air manufacturer, which as pretty much the same answers (and descriptive statistic). If we want to understand why they would like for the people that agree with this sentence, the majority of them will say that it is in continuity with the earth protection trend against global warming by participating in the worldwide effort. More precisely from these answers, we can notice that some of them want to apply the principle of the one that pollutes pays, but from others, it is more related to the self-consciousness of passengers. In other words, they know when they flight how weight they responsibility in global warming and then, from that found alternatives... to meet a good deal between still continue for aviation to reach their original goals by creating the link and relation between worldwide populations and also to switch the flight to more sustainable ones. In addition, if we look at what passengers see as an outdated practice on board or on the airport it is first the too much usage of plastic that is barely recycled on board, but also the fact that airliners always

give too much stuff, which is often overpackaged, that are not really needed during flights. It might be better if people have more freedom to bring their own objects inboard, and so avoid distributed this too many items nonessential from airliners. Additionally, the food served comes generally from the other side of the planet so that caused a lot of unnecessary transportation and so environmental impact. Also, the management of the plane with the speed that can be decreased to pollute less, the very rare usage of biofuel, fuel dumping, and the over usage of the engine on runways and taxi steps. Then one flight attendant that responded to the survey highlighted that the carbon compensation is more a marketing operation than a real process clearly set up, in the way that airliners pay society that will just plant the trees but not even follow if it grows correctly. Finally in the airport passengers noticed that the light is too much turned on, and many other structures that are overused like speed-walk running without stop, but also too many shuttles are not fully electrical.

Thereafter, we came back for a couple of Likert scaled questions to narrow what people are able to react in his scale. For the food, passengers agreed with the way that they are willing it less packaged, the standard deviation also show that they are majority concentrated on the side of the agreement with the proposal. Then for the question of boarding earlier in order to let a push tractor lead the plane until the runway in order to save fuel, people agreed with this they are able to do so and it's the answer that a lot of them gave as we see the lowest rate of sigma at  $\sim 0,8$  that's means a very high concentration of people around here. Next, if we look at the question of taking an airplane smaller that runs with electric energy, respondents also agree with it, and by still staying on the agreed side as the standard deviation is  $< 1$ . Moving on to the fact of avoiding flights with a transfer, it's not surprising that the extent is from "Disagree to Strongly Agree", it means that no one wants to take always flights with a transfer from A point to a C point through a B point. In fact, the means are just under the agreement. They still answered with a standard deviation under 1 so let's say that is for the big majority of people give credit to this solution. Finally, for the last option that the aeronautics industry can consider, as it is really expensive and hard to set up (creating more airports with fewer destinations), the means decrease smoothly to be almost in between the neutral position and the agreement. It is reflecting on the deviation that is now back, more than 1, meaning that there is a part of them that disagree with this last solution (c.f. Appendix 2, graph 9).

Thereupon, passengers had to give their opinion about the 3 models of aircraft that Airbus presented with this Zero-emission and hydrogen aircraft, to see in which case they are more likely to fly with. For the long-haul, it seems people are mainly willing to take the B (with open rotor) and C planes (more standard shape) at 1/3 for the B and even more with C ~45 %. In a nutshell, passengers preferred to stay in an aircraft that they already know at least for the long run than going to a more innovative model (c.f. Appendix 2, graph 10). Then if we compare with the short and middle haul-flights, it seems that people are more open to travel in an innovative model such as the picture A (delta wings model) with 45 % around, of potential respondents' interest. But they are also interested in the open rotor aircraft, but not so much (only ~10 %) in really standard shape of existing airplanes (c.f. Appendix 2, graph 11). Finally, from these images, a couple of questions were asked still on a Likert scale. The first one is concerning the three pictures that will likely run with hydrogen energy. As the liquid hydrogen requires a lot of volume, passengers will not have so much space as in an aircraft conducted with kerosene. Therefore, people are here for the first time more on the disagreement side. However, the means is still close to the neutral position. Indeed, there is a concentration of answers a little bit up than one scale, in other words, travelers are shared between "Agree and Disagree" with the affirmation. Additionally, the following question related to picture B, we will take the result with a very high carefulness, as one respondent noticed that the question was turned by the negative and this fact can be confusing. In reality when the respondent answers disagree it is equivalent to say that he is ready to board an aircraft with an open rotor. So, if we might expect that passengers had well understood the situation, the majority of them are okay to take a plane that has an open rotor even if the noise increased. Finally, for the last question, we saw that people are "Neither Agree nor Disagree" to do more stopovers if the industry cannot find an adequate solution to have a low consumption that allows long flight without stopover. Indeed, the standard deviation is nearly one meaning that people can be balanced from each side with the ones that simply agree and the rest that disagrees (c.f. Appendix 2 graph 9).

## 7 RECOMMENDATIONS

According to the answers of the survey, the industry and airlines must follow some piece of advice. First, the airlines have to be aware of customer reality concerning the global emission caused by the air traffic, as most of the time people gave such huge figures that overestimate its share. Also, it can be really relevant to be aware of people's own responsibility for every single flight when they travel by plane, as many of them are not positioned (neutral) with the idea of giving a donation, so we can have more donations if we may market it more. But then if the additional cost becomes mandatory people are a little bit less enthusiastic about this idea, but still in a neutral position. So, we recommend to first try to use the marketing and promotion techniques to show to the large audience that they can be an actor to fight against climate change. Then if it does not really change, passengers should pay systematically this cost, and it can be good as well as we know some respondents liked the principle of polluter that pays. Nevertheless, it should stay balanced to be suitable and still gathering people. Further, in general, passengers judged outdated many practices within the airport, during the flight, and even in the runways. The primordial thing is to recycle the waste onboard and also give less unnecessary items, overpacking it... then the second important thing is to use more and more renewable energy at each step that it is possible to apply in order to avoid fossil energies. The industry can also have a deeper exploration of the solution of pushing tractor that leads the plane until the runway, to find out a solution for the warmup time. Moving one to the last solution that the industry can consider, we recommend in that case for industry to adopt the smaller airplanes solutions but still in the airport that have the same size as at the moment. Also have only direct routes instead of flights with transfer can really be positive for people and for saving energy. From the three proposals of Airbus to implement its hydrogen aircraft, it looks like the Delta wing model will be only suitable for short and middle run, whereas the standard model is more seen for the long-run purpose only and finally the open rotor could be well welcome for both purposes. Indeed, people may be (because of the possible bias) really interested to fly with an open rotor aircraft, that less affects the earth. At last, for the three models, it seems that passengers don't have any fixed position to do many flights for restocking hydrogen in the airplane, so it can be considered. But for reducing the space on board it looks hard to impose on

people. So, it's in the hand of the industry that must find the ideal solution to reach each side's expectations.

## 8 CONCLUSION & SUMMARY

In conclusion, this thesis handles a wide concern of nowadays, the sustainability within the aeronautics industry. This topic is indeed at first look more suitable for a Master's thesis, especially if it's a double degree student in the Business and Engineering curriculum. However, we arrived at our level, to complete many of our goals already set up. Thus, as we know better the expectations of customers in terms of what they want. This comes from the well-explained theoretical part, as we mainly understood the habits and concerns of the industry from the early stages at the beginning of the 20th century. Briefly, we can say that the industry faced three major crises during the timeline, and each time it's a new time to rebuild itself. The first one was the oil crisis in the 60's that allow the industry to invest a lot in Research and Development. In the early 2000's the Twin towers terrorist attack changed totally the procedures for passengers when they are boarding an aircraft and it was even more difficult as the industry was suffering from the decreasing of purchasing power with the Subprime crisis. As a consequence, LCC appears with a new economic model, offering multiple short and middle haul flights for cheap. Nowadays, the industry is facing the pandemic of coronavirus, so it's a good time to remove the old polluter aircraft to switch from the new one that takes into consideration the environment such as with the hydrogen energy currently experimented by Airbus. From that, we approach in the questionnaire the three possible axes of innovation, the carbon compensation that was covered in the questionnaire, and now the industry knows how to smoothly try to implement it in the customer mind. Then from the optimization techniques, we saw that the majority of people are willing to do something at their scale and now it's on the responsibility of the industry to inform more the customer how he can help, by for example economies of scale. And lastly, as the customer cannot directly act on the technological innovations, we have a better known of which one, the industry has to focus on, for example, which model of aircraft is the most

suitable for them. We clearly find out from that, the fact for the customer that usually wants to keep the same comfort as before, with the same space on board but can do more indirect concessions such as boarding earlier, which will not have a strong effect during all his travel. So now if we refer to the problem asked at the beginning of the thesis, we can affirm that we have pretty much all the answers. Maybe only the real added value was not so even studied from the questionnaire as the survey itself was only concerning the environmental purpose. In sum, it was already narrowing the study from the beginning. Now we know better what customer want from this specific subject, and indirectly the industry understands that things have to take time to be set up, and the scenario of green aviation is not already all planned it will be varied from the new needs of the population but also the technical constraint and new findings or improvement of the aircraft manufacturer but also don't forgot the airlines that have to do their best to make the balance between profitability and where they can gain from sustainability. It's always a of deal between demand and supply, to reach the best solution for every actor.

## 9 LAST WORDS

As final sentences, we can highlight that this thesis covers in the theoretical part, and pretty much the customer point of view in the survey. So, to go further in the study, someone can for example, taking the survey adapt it and through the recommendations and analysis, directly ask the interested person or company like Airbus to see if the customer expectations are achievable or not. Finally, we can guess that a researcher with more technical knowledges can approach easily all the purposes related to components of the subset, thus, to narrow more the topic with concrete set up of the theoretical aspect, by knowing what the technical boundaries could be forgotten.



## 10 BIBLIOGRAPHY

Aerospace. (2018, June 01). A brief history of space exploration. Récupéré sur Aerospace: <https://aerospace.org/article/brief-history-space-exploration>

Airbus. (2021). Airbus Annual General Meeting 2021. General Meeting 2021. Toulouse.

Airbus Group. (2020, September 21). Airbus reveals new zero-emission concept aircraft. Récupéré sur Airbus: <https://www.airbus.com/newsroom/press-releases/en/2020/09/airbus-reveals-new-zeroemission-concept-aircraft.html>

ATAG. (2020). CO2 emissions for 2050.

Ayoun, L. (2021). Quelle est l'empreinte carbone d'un vol en avion ? Récupéré sur Hello Carbo: [https://www.hellocarbo.com/blog/calculer/empreinte-carbone-avion/#Les\\_3\\_chiffres\\_a\\_retenir](https://www.hellocarbo.com/blog/calculer/empreinte-carbone-avion/#Les_3_chiffres_a_retenir)

Baily, M. N., Litan, R. E., & Johnson, M. S. (2008). The Origins of the Financial Crisis. Brooklyn: Business and Public Policy.

Bombardier Aéronautique. (2021). Qui sommes nous ? Récupéré sur Bombardier: <https://bombardier.com/fr>

Charente Mongolfières. (2021). Histoire de la Mongolfière. Récupéré sur Charente Mongolfières: <https://www.charente-montgolfieres.fr/qui-sommes-nous/histoire-de-la-montgolfiere/>

Churchill, G. A., & Lacobucci, D. (2002). Marketing research: Methodological foundations. South-Western Publishing Company.

Comac China. (2021). Company Profile - Introduction. Récupéré sur Comac: <http://english.comac.cc>

Dumez, H.-O. (2021, May 7 ). Toulouse. Face aux écologistes, le patron d'Airbus monte en première ligne pour défendre l'aviation. Récupéré sur Actu Toulouse: [https://actu.fr/occitanie/toulouse\\_31555/toulouse-face-aux-ecologistes-le-patron-d-airbus-monte-en-premiere-ligne-pour-defendre-l-aviation\\_41616985.html](https://actu.fr/occitanie/toulouse_31555/toulouse-face-aux-ecologistes-le-patron-d-airbus-monte-en-premiere-ligne-pour-defendre-l-aviation_41616985.html)

Dumont, J. B. (2021, January 10). QUELLES INNOVATIONS COURT & LONG TERME POUR AIRBUS ? Entretien avec JB Dumont, directeur ingénierie. (X. Tytelman, Intervieweur)

Embraer. (2021). About us ? Récupéré sur Embraer: <https://embraer.com/global/en>

France 3 Occitanie. (2020, August 2). A Toulouse, le spectre des licenciements continue à planer sur les salariés d'Airbus. Récupéré sur France 3 Occitanie: <https://france3-regions.francetvinfo.fr/occitanie/haute-garonne/toulouse/toulouse-spectre-licenciements-continue-planer-salaries-airbus-1859176.html>

French Government. (s.d.). Le Français Clément Ader parvient à faire décoller "Éole", le premier avion. Récupéré sur Gouvernement Français: <https://www.gouvernement.fr/partage/9572-le-francais-clement-ader-parvient-a-faire-decoller-eole-le-premier-avion>

Frigant, V., Kechidi, M., & Talbot, D. (2006). Les territoires de l'aéronautique : EADS, entre mondialisation et ancrage. L'Harmattan.

Godenne, M. (2019, January 24). Industrie Aéronautique. Récupéré sur Planilog: <https://www.planilog.com/fr/blog/industrie-aeronautique>

Gourdin, K. N. (2015). A Profile of the Global Airline Industry. Business Expert Press.

Guénon, V. (2021, February 12). SAFRAN : LE TEMPS DES DEFIS ! entretien avec V. Guénon, directrice politique environnementale. (X. Tyltelman, Intervieweur)

ICAO. (2015). Evolution du nombre de passagers aériens mondiaux.

Inxelo Technologies. (2020). Aviation recap of the 2010-2019 decade. Récupéré sur Voice: <https://voice.inxelo.aero/index.php/2019/12/30/aviation-recap-of-the-2010-2019-decade/>

Klaas, B. (2021, January 15). Aéronautique : comment la double crise sanitaire et climatique peut-elle accélérer la résilience ? Récupéré sur Journal du Net: <https://www.journaldunet.com/economie/transport/1496825-aeronautique-comment-la-double-crise-sanitaire-et-climatique-peut-elle-acceler-la-resilience/>

Kotler, P. (2015). Marketing Management 15th edition. Pearson Education Ltd.

LeonardodaVinci.net. (2021). Leonardo Da Vinci's Dream of Flying. Retrieved from Leonardo da Vinci: <https://www.leonardodavinci.net>

Louis, P., & Tanca, L. (2019, July 10). QUEL EST LE POIDS DES TAXES SUR UN BILLET D'AVION ? Récupéré sur BFMTV: [https://www.bfmtv.com/economie/economie-social/quel-est-le-poids-des-taxes-sur-un-billet-d-avion\\_AN-201907100103.html](https://www.bfmtv.com/economie/economie-social/quel-est-le-poids-des-taxes-sur-un-billet-d-avion_AN-201907100103.html)

Marcel. (2013, December 28). Programme d'entraînement aérien du Commonwealth. Récupéré sur Avions Légendaires: <https://www.avionslegendaires.net/dossier/programme-entrainement-aerien-du-commonwealth/>

Meddah, H. (2021, April 13). La crise du Covid a fait plonger de 30% l'activité aéronautique française en 2020, selon le Gifas. Récupéré sur L'Usine nouvelle: <https://www.usinenouvelle.com/article/la-crise-du-covid-a-fait-plonger-de-30-l-activite-aeronautique-en-2020.N1081549>

- Ministère de la Transition Écologique. (2021). TendancIEL 2020. Paris.
- Nouveau, P. (2017). Introduction to the European Economy . Bruxelles: Deboeck.
- Pigaillem, C. (2014). Les dates clés de l'aéronautique . Dijon.
- Pollet, F. (2021, January 28). <https://www.ipsa.fr/blogs/2021/01/futur-avion-livre-francis-pollet/>. Récupéré sur IPSA: « Le futur de l'avion », le livre qui décrypte les prochains défis de l'aéronautique
- Rakotondrabe, A. (2018, October 11). L'histoire fascinante du ballon dirigeable, pionnier de l'aviation civile. Récupéré sur Daily Geek Show: <https://dailygeekshow.com/ballon-dirigeable-giffard/>
- Saunders, M., Lewis, P., & Thornhill, A. (2012). Research Methods for Business Students. Harlow: Pearson Education Ltd.
- Science Po. (2020, August 31). Les conséquences du 11 septembre sur les relations. Récupéré sur Science Po - Bibliothèque: <https://www.sciencespo.fr/bibliotheque/fr/rechercher/dossiers-documentaires/apres-11-septembre.html#3Relations>
- Sympa (Réalisateur). (2021). Pourquoi il n'y a Pas Encore d'Avions Électriques [Film].
- Tenoux, N. (2021, Avril 14). LE DÉFI ENVIRONNEMENTAL DE L'AVIATION - impacts et enjeux.
- Tyltelman, X. (2020, November 17). 8 LEVIERS POUR RÉDUIRE LES ÉMISSION DE CO2 DE L'AVIATION DE 25% D'ICI 2030 SANS CHANGER LES AVIONS.

Questionnaire- Forms

“Hello, currently on academic exchange at SAMK in Finland, I have to do a thesis for my 3rd year of double degree in International Business.

Thus, I am conducting a survey on the carbon emissions generated by aviation.

That's why I invite you to answer this questionnaire. It will take you about 6 minutes to complete it.

Don't worry, the answers will be treated anonymously.

Thank you in advance.”

1. Which language do you speak?
  - French
  - English
  
2. For which purpose do you mostly travel?
  - Leisure
  - Business reasons
  - Other {recoded in function of the answers}
  
3. Did you travel at least one return flight per year before 2020 (before Covid-19)?
  - Yes
  - No (stop the questionnaire)
  
4. In which class do you usually travel?
  - Economy
  - Premium economy
  - Business
  
5. Are you aware of the carbon emission caused by the aeronautics industry?
  - Yes
  - No (go to the question 7 directly)

6. How many % of the total global emission does it represent?

Give a figure

{For all} “If we consider only CO<sub>2</sub>, then aviation generates about 2.5% of global carbon emissions. But if we include all greenhouse gases, including nitrogen oxide emissions, we get 3% of total emissions. However, this is less than the pollution generated by the textile sector or the use of the Internet.”

7. Would you like to be informed of your carbon footprint for each one of your flights?

-Yes

-No

8. I would be willing to give a donation after purchasing the ticket to compensate for my travel footprint.

-Strongly Disagree

-Disagree

-Neither Agree nor Disagree

-Agree

-Strongly Agree

9. I think that this kind of additional cost (to compensate for my travel footprint) should be mandatory, at least while waiting for the industry to create adequate innovations to decrease the emission.

-Strongly Disagree (Directly go to question 11)

-Disagree (Directly go to question 11)

-Neither Agree nor Disagree (Directly go to question 11)

-Agree

-Strongly Agree

10. Please explain why.

Free text answer

11. Can you name some practice that you think is outdated regarding the waste of energy in the airport or on board?

Free text answer

12. I would not mind if the serviced food would be less packaged than now.

-Strongly Disagree

-Disagree

-Neither Agree nor Disagree

-Agree

-Strongly Agree

“Did you know that? Even something as simple as going to the bathroom before a flight could, through economies of scale, reduce global kerosene consumption by about 50,000 tons. That's if everyone adopted this good practice.”

13. I would be ready to board the plane earlier so that it could be conducted by an electric truck to join the runway. (Thus to save fuel)

-Strongly Disagree

-Disagree

-Neither Agree nor Disagree

-Agree

-Strongly Agree

14. I would be ready to board a smaller aircraft that can run with electrical energy.

-Strongly Disagree

-Disagree

-Neither Agree nor Disagree

-Agree

-Strongly Agree

15. I would be willing to take more direct flights without layover and pay a little bit more, to avoid taking two flights instead of just one, at the moment.

-Strongly Disagree

- Disagree
- Neither Agree nor Disagree
- Agree
- Strongly Agree

16. I would prefer to have a larger number of moderate-sized airports in the world, but which would then serve fewer destinations. In order to accommodate renewable energy aircraft.

- Strongly Disagree
- Disagree
- Neither Agree nor Disagree
- Agree
- Strongly Agree

17. Airbus is trying to implement an aircraft for 2035 that runs with hydrogen, which of the three aircraft models (types) do you feel the most comfortable to travel in for the long run.

- Picture A
- Picture B
- Picture C

18. What about for a middle or short-haul flight, which of the three aircraft models (types) would you feel most comfortable traveling in?

- Picture A
- Picture B
- Picture C

19. I would be ready to have less space on board, as the hydrogen requires volume.

- Strongly Disagree
- Disagree
- Neither Agree nor Disagree
- Agree
- Strongly Agree

20. I would not like to travel in a plane with an “open rotor”, because it makes more noise and will disturb me, even if it would consume less fuel.

- Strongly Disagree
- Disagree
- Neither Agree nor Disagree
- Agree
- Strongly Agree

21. Later, when the hydrogen aircraft will be ready, I would be ready to do more stopovers in order for the aircraft to restock hydrogen.

- Strongly Disagree
- Disagree
- Neither Agree nor Disagree
- Agree
- Strongly Agree

22. What is your socio-professional category?

- Agriculture
- Craftman, merchant and business owner
- Employee
- Executive, manager and higher intellectual professions
- Middle professions (teachers, nurses...)
- Retired
- Student
- Others (recode in function)

23. How old are you?

- Between 18-25
- Between 26-35
- Between 36-45
- Between 46-55
- Between 56-64
- 65 and older

24. I am...

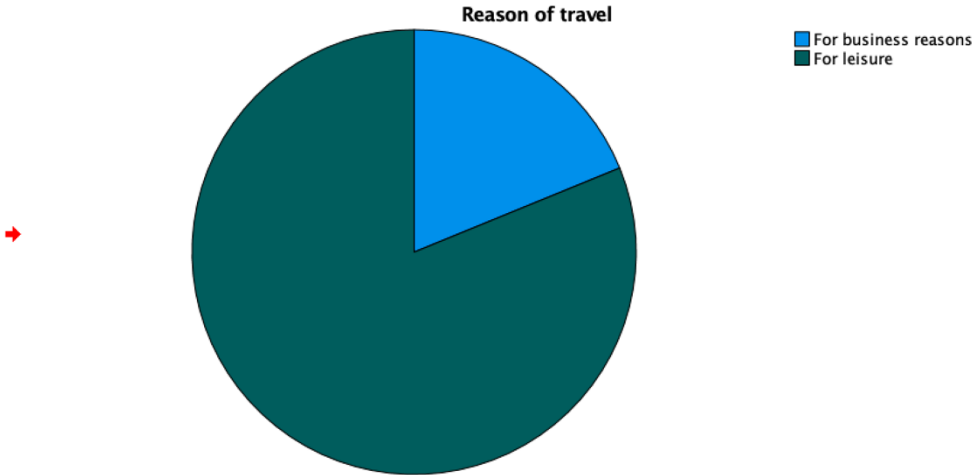
-Male

-Female

List of the SPSS graphs for analysis

**Reason of travel**

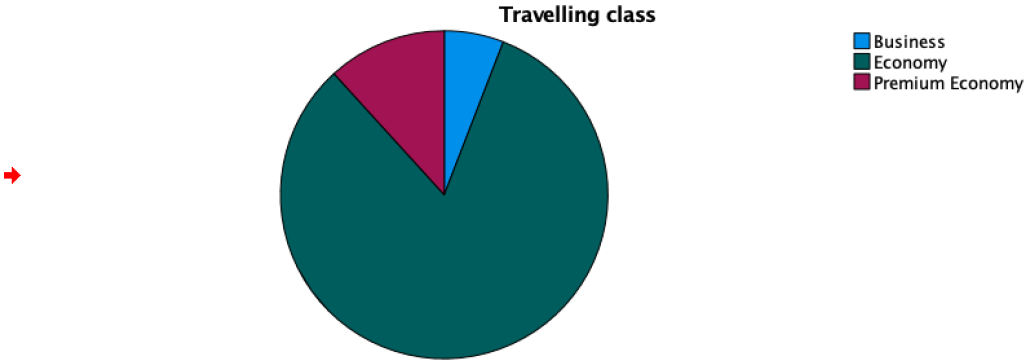
	N	%
For business reasons	16	18,8%
For leisure	69	81,2%



Graph 1: Purpose of the travel (Gaveau Antonin, 2021)

**Travelling class**

	N	%
Business	5	5,9%
Economy	70	82,4%
Premium Economy	10	11,8%

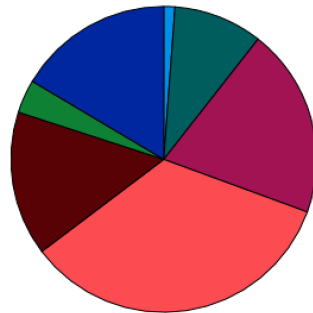


Graph 2: Travelling class taken by passengers (Gaveau Antonin, 2021)

**Profession**

	N	%
Agriculture	1	1,2%
Craftsman, merchant and business owner	8	9,4%
Employee	17	20,0%
Executive, manager and higher intellectual professions	29	34,1%
Middle professions (teachers, nurses...)	13	15,3%
Retired	3	3,5%
Student	14	16,5%

**Profession**



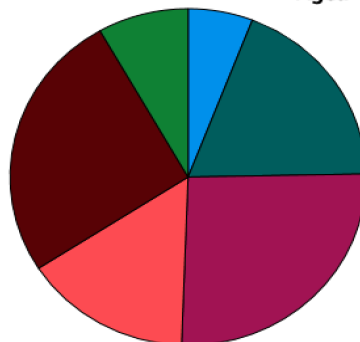
- Agriculture
- Craftsman, merchant and business owner
- Employee
- Executive, manager and higher intellectual professions
- Middle professions (teachers, nurses...)
- Retired
- Student

Graph 3: Socio-professional category of the respondents (Gaveau Antonin, 2021)

**Aged**

	N	%
65 and older	5	5,9%
Between 18-25	16	18,8%
Between 26-35	22	25,9%
Between 36-45	13	15,3%
Between 46-55	22	25,9%
Between 56-64	7	8,2%

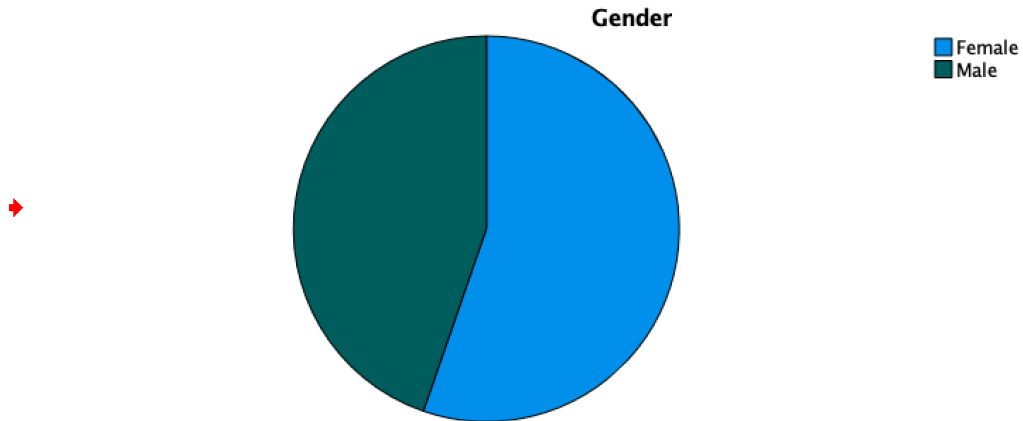
**Aged**



- 65 and older
- Between 18-25
- Between 26-35
- Between 36-45
- Between 46-55
- Between 56-64

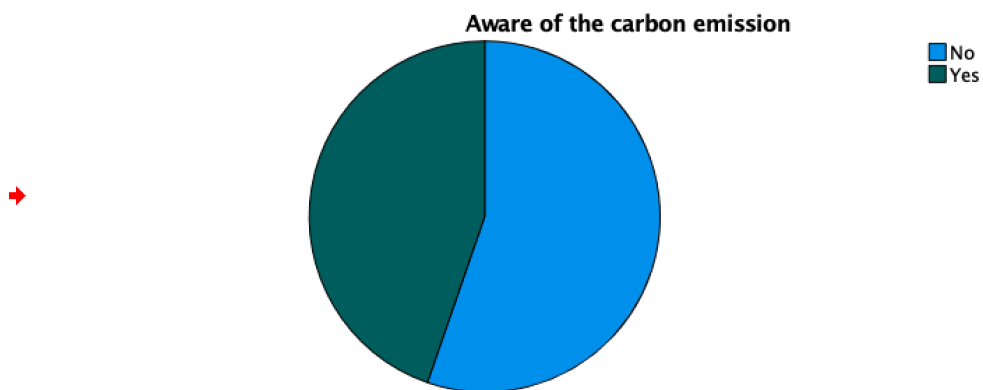
Graph 4: Age of the respondents (Gaveau Antonin, 2021)

Gender		
	N	%
Female	47	55,3%
Male	38	44,7%



Graph 5: Gender of the respondents (Gaveau Antonin, 2021)

Aware of the carbon emission		
	N	%
No	47	55,3%
Yes	38	44,7%

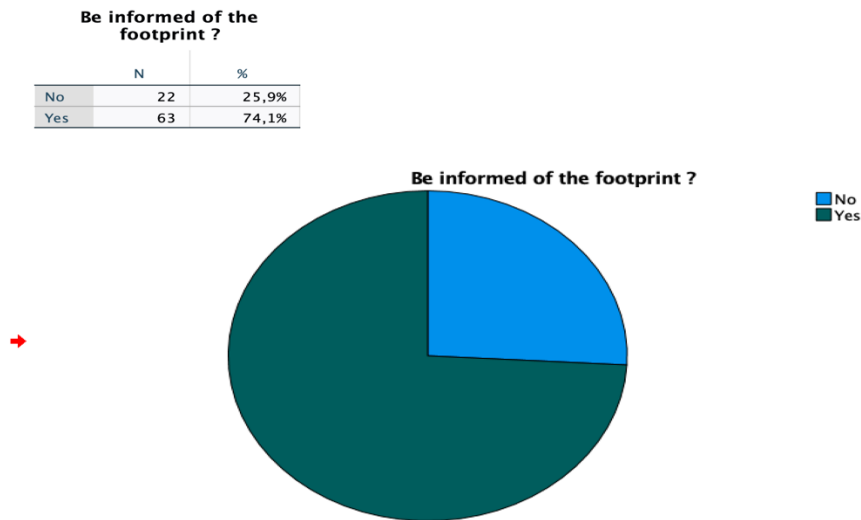


Graph 6: Awareness of the traveler about carbon emission (Gaveau Antonin, 2021)

### Statistiques descriptives

	N	Minimum	Maximum	Moyenne	Ecart type
Percentage	34	2	90	21,74	24,713
N valide (liste)	34				

Graph 7: Beliefs of passengers about total aviation emission (Gaveau Antonin, 2021)



Graph 8: Desire of passengers to be informed of their footprint (Gaveau Antonin, 2021)

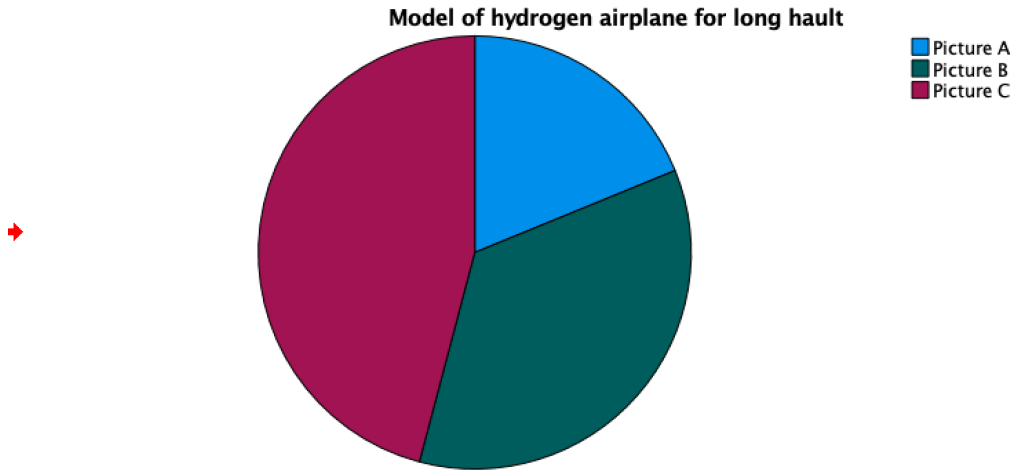
**Statistiques descriptives**

	N	Minimum	Maximum	Moyenne	Ecart type
Give a donation for compensate ?	85	1	5	2,82	1,125
This should be mandatory ?	85	1	5	2,80	1,242
Less food packaging ?	85	1	5	4,04	1,159
Board earlier for push by tractor ?	85	1	5	4,21	,888
Smaller plane that run with electrical energy ?	85	1	5	4,00	,951
No transfert flight ?	85	2	5	3,96	,993
More airports, fewer destinations ?	85	1	5	3,67	1,051
Less space on board ?	85	1	5	2,81	1,149
Travel in airplane with Open rotor ?	85	1	5	2,55	1,006
More layovers with hydrogen aircraft ?	85	1	5	2,93	1,055

Graph 9: Likert scale questions (Gaveau Antonin, 2021)

**Model of hydrogen airplane for long haul**

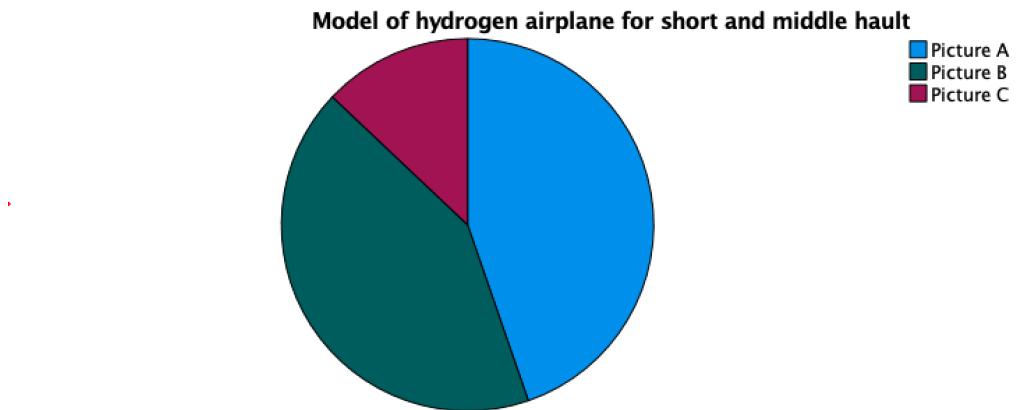
	N	%
Picture A	16	18,8%
Picture B	30	35,3%
Picture C	39	45,9%



Graph 10: Preference of aircraft for long-run flight (Gaveau Antonin, 2021)

**Model of hydrogen airplane for short and middle haul**

	N	%
Picture A	38	44,7%
Picture B	36	42,4%
Picture C	11	12,9%



Graph 11: Preference of aircraft for short/middle run (Gaveau Antonin, 2021)