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Towards a Fly Net-Zero Future: A comparison between Wizz Air and Ryanair

Prof. Francesca Vicentini

SUPERVISOR

Marco Giovannini - 307801

CANDIDATE

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Abstract

Nowadays, climate change is a primary issue, calling to action the present generation for sustainable initiatives. Air travel is a key player capable of connecting individuals and economies worldwide, but it is also a significant contributor to climate change through greenhouse gas emissions, noise pollution and air quality concerns. As global sustainability targets in particular the Paris Agreement and EU Climate Directive, are urging like never before the airlines to mitigate their environmental emissions. With the aim of investigating and exploring the future of aviation towards fly net-zero emissions by 2050. This work explores how the aviation, especially the airline industry is moving forward to comply with the following target, exploiting a comparative analysis of sustainability between Wizz Air and Ryanair to examine the key sustainability indicators. Although, the findings underscore that different strategies and initiatives have been embraced by the mentioned airlines and by the main stakeholders, the aviation is not completely qualified to meet the net-zero transition.

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List of Abbreviations

ATAG	Air Transport Action Group
ATJ	Alcohol-to-Jet
AZEA	Alliance for Zero-Emission Aviation
BC	Black Carbon
CAPA	Centre For Asia Pacific Aviation
CDP	Carbon Disclosure Project
CORSIA	Carbon Offsetting and Reduction Scheme for International Aviation
CSRD	Corporate Sustainability Reporting Directive
EASA	European Union Aviation Safety Agency
EC	European Commission
EFTA	European Free Trade Association
EIONET	European Environment Information and Observation Network
EMEA	Europe, Middle East and Africa
END	Environmental Noise Directive
EOD	Earth Overshoot Day
ESG	Environmental, Social and Corporate Governance
EU	European Union
FT	Fischer-Tropsch
GDP	Gross Domestic Product
GHG	Greenhouse Gases
HC	Hydrocarbons
HEFA	Hydroprocessing of Esters and Fatty Acids
IATA	International Air Transport Association
ICAO	International Civil Aviation Organization
IEA	International Energy Agency
IPCC	Intergovernmental Panel on Climate change
ITF	International Transport Forum
LCC	Low-Cost Carriers
LNG	Liquefied Natural Gas
NFRD	Non-Financial Reporting Directive
PM	Particular Matter
RPK	Revenue Passenger Kilometer
SAF	Sustainable Aviation Fuel
SASB	Sustainability Accounting Sustainability Board
SDG	Sustainable Development Goals
SWOT	Strengts, Weaknesses, Opportunities, Threats
UN	United Nations
UNFCCC	United Nations Framework Convention on Climate Change
UPF	Ultrafine Particles
USD	United States Dollars
VOC	Volatile Organic Compounds
WHO	World Health Organization
WWF	Worldwide Fund for Nature

Introduction

This thesis aimed to draw attention to the main concern of the current era, climate change. Looking for a brighter future, towards fly net-zero emissions by 2050. The reason for choosing this topic was related to the importance of disclosing such a relevant issue, contributing to mitigating climate change and underlining its relevance. In a phase of fast economic and development growth, air travel is a key player capable of connecting individuals and economies worldwide; hence, it has a substantial impact on global warming, contributing to roughly 2.5% of global CO_2 emissions which are expected to grow due to continuous development. Therefore, in order to respect the environment, it is crucial to embrace corporate sustainable initiatives, especially in the aviation industry. Considering the current climate change urgency and the growth in the importance of sustainability among industries, airline companies are adopting sustainable practices to lessen their emissions.

The matter has been approached through a comparative analysis of sustainability between two low-cost airlines, Wizz Air, as a sustainability pioneer in civil aviation and Ryanair as the largest low-cost airline in Europe, with the aim of examine their key sustainability indicators.

The first chapter explores the evolution of the sustainability concept from its origin (United Nations, 1972) to shaping the three pillars of sustainability: environmental, social, and economic. Following the introduction, it analysed the concept of climate change, mentioning the different changes that can be caused to the atmosphere and environment. Revealing the value and benefits of implementing sustainable strategies and initiatives in day-to-day business operations.

Chapter 2 firstly introduces the concept of the aviation industry and airlines, then explores the relative impacts on climate change (i.e., noise pollution, air quality). Secondly, it identified the key practices to mitigate emissions, mainly through the adoption of green fuels.

In Chapter 3, a business case has been developed regarding Wizz Air, with a brief overview of the airline then focusing on its sustainable initiatives and strategies, reporting its decarbonisation pathway.

Chapter 4 firstly analysis the second business case of Ryanair, with a brief overview of the airlines, then focusing on its net-zero emission's pathway. Secondly, a comparative sustainable analysis was conducted between these two airlines, to examine their sustainability performance.

Lastly, Chapter 5 presents a deep outlook on the future of the aviation industry and its possible actions to secure net-zero emissions by 2050. This work concludes with some final observations

on opportunities and threats for an effective achievement of fly net-zero target, supported by a Bain & Company case study.

1. Foundation of Sustainability

The 1970s were marked by the global energy crisis, but the idea of the Earth's limited capacity became apparent in the 1970s when the Club of Rome published "The Limits to Growth," which established the need for society to understand Earth's physical limitations (Robinson, 1973), resulting in public promotion of sustainable actions. The United Nations defined sustainability as a concept in 1972, while the Brundtland Report's 'Our Common Future' introduced the concept in 1987, before developing into an essential principle that requires leaders and everyone today to link future needs with present requirements through the principle of “Sustainable Development.” The awareness of the finite capacity of Earth's biocapacity is the primary factor behind sustainable development trend advancement because population growth combined with consumer spending and resource depletion causes permanent damage which needs to be addressed by this generation. We currently inhabit an unsustainable world where we exceed the Earth's capacity to provide resources. When discussing the reduction of resources, mentioning Earth Overshoot Day is relevant, as it takes place earlier every year. Earth Overshoot Day (EOD) marks, when human resource usage exceeds nature's ability to regenerate throughout the year thus indicating we have exceeded the Earth's capacity. Earth Overshoot Day for the year 2024 arrived on August 1st. Through the passing years, this specific date has gradually shifted from January 1st to August 1st. The only way, to delay Earth Overshoot Day is therefore to conserve natural resources, use renewable energy, and practice sustainable consumption. Each year, the Global Footprint Network determines Earth Overshoot Day by calculating how many days the Earth’s biocapacity can fund the human ecological footprint. The stage of the year after this date represents ecological deficit, also known as ecological overshoot periods.

It is defined in the following way:
(Earth’s Biocapacity / Humanity’s Ecological Footprint) * number of days in the year = EOD.

As Figure 1-1 below displays, Earth Overshoot Day started occurring in late December during the 70s. This declining trend emphasises the essential need to improve sustainability on the planet, cities, energy, food, and population to move the Earth Overshoot Day date, and lessen resource depletion.

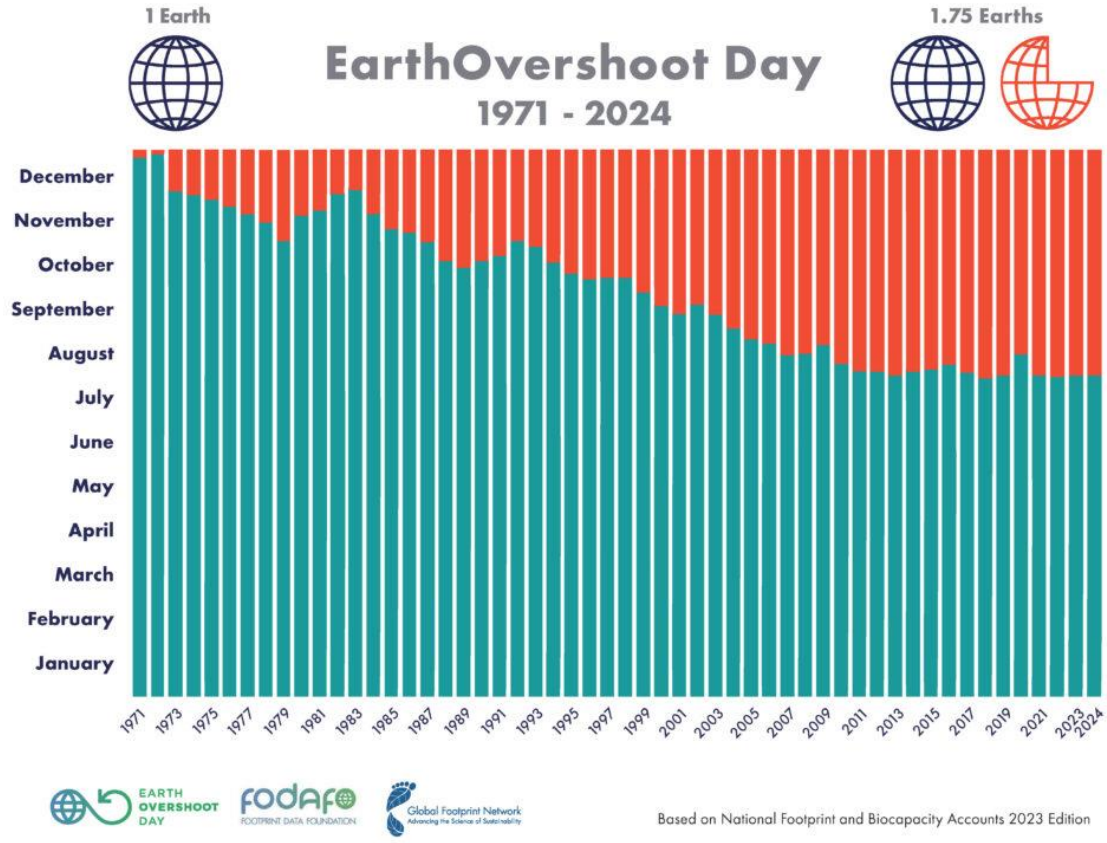


Figure 1-1: Earth Overshoot Day from 1971 to 2024.
Source: https://overshoot.footprintnetwork.org/

Naturally, the progress in economic development, the growth in greenhouse gas (GHG) emissions, and the companies' focus on further growth and profits are the major challenges to the climate: climate change. Sustainability can be classified into three categories due to the wide range of sectors it affects and the risks it poses to economic growth, for example, inequality. Therefore, sustainability makes a case for the adoption of a coherent approach to what is referred to as "sustainable behaviour" in relation to the dimensions, and more specifically to focus on environmental issues, protect human rights, and prefer long-term advantages to short-term advantages.

1.1. Concept of Sustainability

The core definition of sustainability as a concept remains connected to development: sustainable development is defined as the process of meeting present needs without compromising the ability of future generations to meet their needs [World Commission on Environment and Development 1987, 43]. According to the Commission, both present and

future generations stand on equal ground in terms of needs, and development is constrained by technological capabilities, organisational frameworks, and planetary resource limitations. The study proposed shifting focus from conventional brief economic horizons to evaluate consequences that future generations might encounter many decades into the future. This method moved towards a perspective that expanded sustainability analysis past socioeconomic systems to include their natural system interactions. Social frameworks alone cannot ensure sustainability because nature's systems provide essential advantages which emerge from their natural processes. Nature provides the essential foundation for sustainability by delivering fundamental processes that, throughout geological history, have created fossil fuels, freshwater, forests, and waste management capabilities, and continues to supply essential services to human populations, including pollination services by bees. Human beings must preserve some natural services through reforestation efforts after logging activities, while other environmental services require protection from harmful human actions through regulations such as the Montreal Protocol, which preserved the ozone layer. Sustainability requires holistic attention because strengthening one system component may cause deterioration in another system component. For instance, Germany's decision to turn off its nuclear reactors creates no decrease in nuclear power risks when the country imports nuclear energy from France. It becomes vital to recognise that reductions in risk simply represent redistributions of danger. Sustainability value depends entirely on how processes such as policies and discussions affect actual material practices, together with their results. The atmosphere responds to total amounts of fossil fuel emissions, together with black and brown carbon emissions, and total deforestation and other land use changes, so results represent the essential outcomes. Considering the Canadian government, along with its industries leading the creation of environmental policies, failed to translate these policies into action, resulting in Canada becoming an international leader in both carbon emissions and "hot air" emissions.

Over the last two decades, sustainability has developed into a discipline, although its definition remains relatively general and applicable in different contexts. The main interpretation of sustainability consists of three main pillars as mentioned before: environmental, social, and economic, which are depicted as intersecting circles. The concept of "three pillars" have been widely applied to many companies, institutions, and government agencies today, including United Nations (UN) and the U.S. Environmental Protection Agency has been a central part of sustainability discourse, which guided the formation of the UN's Sustainable Development Goals (SDG's, see Figure 1-2).

Now, the three pillars of sustainability, along with the concept itself, are subject to different interpretations. However, as for the interpretation of each pillar, they are meant to work together, and the only time sustainability is going to be genuine is when there is harmony between the three pillars. This notion emerged from the balanced range of actions needed to achieve sustainable development goals across environmental, social and economic contexts, contributing to the formulation of the three distinguished pillars. Up to 2001, from the early stages, the literature identified this concept as being in strong correlation with the vision of sustainable development and recalling its basic features (B. Giddings, B. Hopwood, & G. O'brien, 2002).

Figure 1-2: The 17 Sustainable Development Goals.
Source: https://ecodynamics.unisi.it/en/sdgs-sustainable-development-goals/

1.2. Three Pillars of Sustainability

In line with the United Nations vision for development and the adoption of the UN Sustainable Development Goals (SDGs), as mentioned above, the concept of sustainability has evolved to consist of three pillars: environmental conservation, social welfare, and economic prosperity. These categories have become significant due to the need for a comprehensive approach to attain sustainability goals, in these areas. The idea of these foundations has been recognised in

the writings since the beginning of the 2000s as a part of the larger vision for sustainable development that highlights its core elements (B. Giddings, 2002).

An examination of existing research suggests that the concept of sustainability's three pillars has its roots in the stages of sustainability discussions. Its inception can be linked to events like the Brundl Report (1987) Agenda 21 (1992) and the 2002 Earth Summit which together played a role in shaping our current widely accepted perception of sustainability as described by Moldan study in 2012.

Based on these principles of development and its three foundational elements are seen as crucial aspects, for promoting lasting progress in social welfare and economic prosperity while safeguarding the environment. As sustainability becomes a concern, over time governments, policymakers, businesses and individuals have progressively incorporated these foundational elements into their approaches and operations to different extents. To achieve development effectively requires a well-rounded approach that integrates all three pillars to support lasting advancement in all areas (see Figure 1-3).

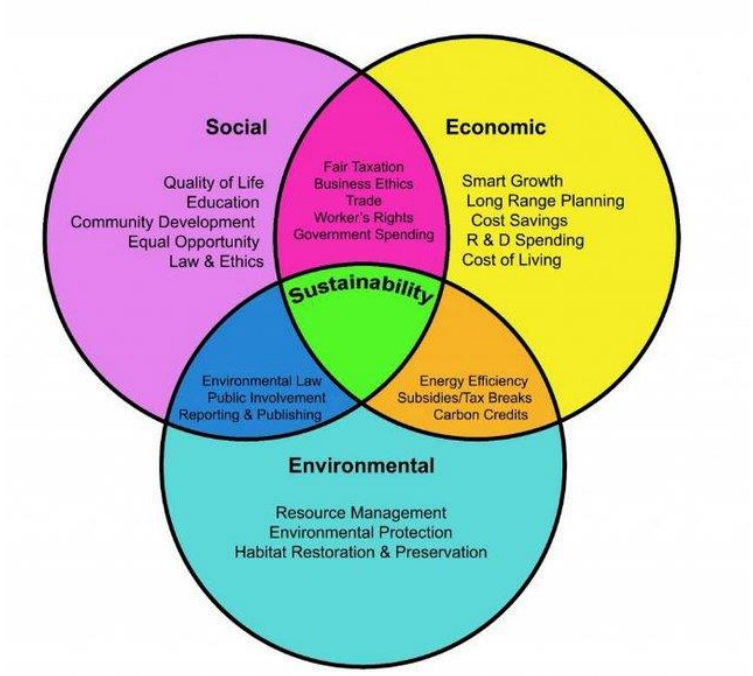


Figure 1-3: Relationships between the three sustainability pillars. Source:https://www.researchgate.net/publication/338610440_Literacy_Promoting_Sustainability_in_a_Digital_Society

1.2.1. Environmental Sustainability

Environmental sustainability focuses on efforts dedicated to preserving and safeguarding the natural environment over time through appropriate practices and policies by mitigating environmental damage and limiting natural resource consumption. Moreover, individual well-being is strictly tied to the surrounding environment, establishing a correlation between human health and environmental conditions.

Pointing out that companies depend on the extraction of natural resources, maintaining their position economically sustainable. Nevertheless, the primary focus of environmental sustainability is to limit resource reduction over time by delaying the Earth's Overshoot Day ensuring the conservation of current resources for future generations. This object can be achieved by lowering fossil fuel usage, conserving water, marine resources, and ecosystems, ensuring clean air quality by decreasing pollution, and optimising recycling execution.

The three sustainability pillars are connected to the others. When one dimension is successful, it directly supports the achievements of other dimension, advancing sustainable development.

1.2.2. Social Sustainability

Social sustainability contains all the creations committed to creating equal opportunity and access for all individuals, to primary need (i.e., water, food, clean air); it encompasses other aspects such as environmental justice, public health, resource security, and education. Within the three sustainability pillars, efforts aiming to enhance social responsibility should also foster economic and environmental welfare. This concept also applies to companies, initiatives to apply social sustainability might prioritise employee retention over economic goals. For instance, investing in employee well-being is likely to generate economic benefits for the firm by boosting employee motivation and satisfaction. Contributing to the increment of social responsibility can also be beneficial for the environment.

1.2.3. Economic Sustainability

Economic sustainability includes all practices devoted to the conservation of natural and financial resources, ensuring financial stability in the long-term. Research indicates that a high employment rate gives a positive impact on both the economy and individuals' social well-being by ensuring resource security through job employment. Consequently, the economic

driving force requiring companies to need employees and people to need jobs can also promote social sustainability and sustainable development, as long as such employment delivers a sense of security.

1.3. Introducing Climate Change

The definition of climate change can be broken down as follows: climate change may be defined as a change in the climate regime, which may be determined (for instance, through statistical analyses) by changes in the mean and standard deviations of relevant quantities, persisted for periods of decades or more. Climate change can be caused by intrinsic processes of the system or by external influences, or by lasting changes in human activities in the atmosphere and on the land surface. On the other hand, in Article 1 of the Framework Convention on Climate Change (UNFCCC), climate change is defined as: "A change in climate that is directly or indirectly caused by human activities that alter the composition of the atmosphere, and that are observed over time scales that are relevant compared to those of natural climate variability." Therefore, the UNFCCC makes a distinction between climate change that is people induced and caused by changes in atmospheric constituents and that caused by natural factors.
The idea that humans can influence global climate change became scientifically valid in the 19th century. Climate change theory has dramatically increased in prominence since the 1970s. In contrast to most hypotheses, which are tested in laboratory environments, climate change is naturally and spontaneously occurring within the earth's system. In the last hundred years, the earth has heated up by more than half a degree Celsius, and the 80s and 90s were the warmest decade. The global climate has risen over the last century, and the increase is likely to continue for the next hundred years. Researchers around the world are charged with watching and measuring, modelling, and analysing changes in the atmosphere and environment.

These changes include:

- A rise in the atmospheric carbon dioxide and other greenhouse gases
- A growth in temperature and the number of days with extreme temperatures, including heat waves
- The melting of snow and ice in the mountainous zones
- A rise in sea level
- More frequent and longer-lasting droughts with higher intensity

- Changes in rainfall patterns
- Effects on ecosystems in the Artic and Antarctic regions
- Increase water temperatures in lakes and rivers
- Spring activations, such as plant growth and bird migrations

This indicates that while some areas will experience longer growing seasons, others will face shorter seasons with more frequent droughts.

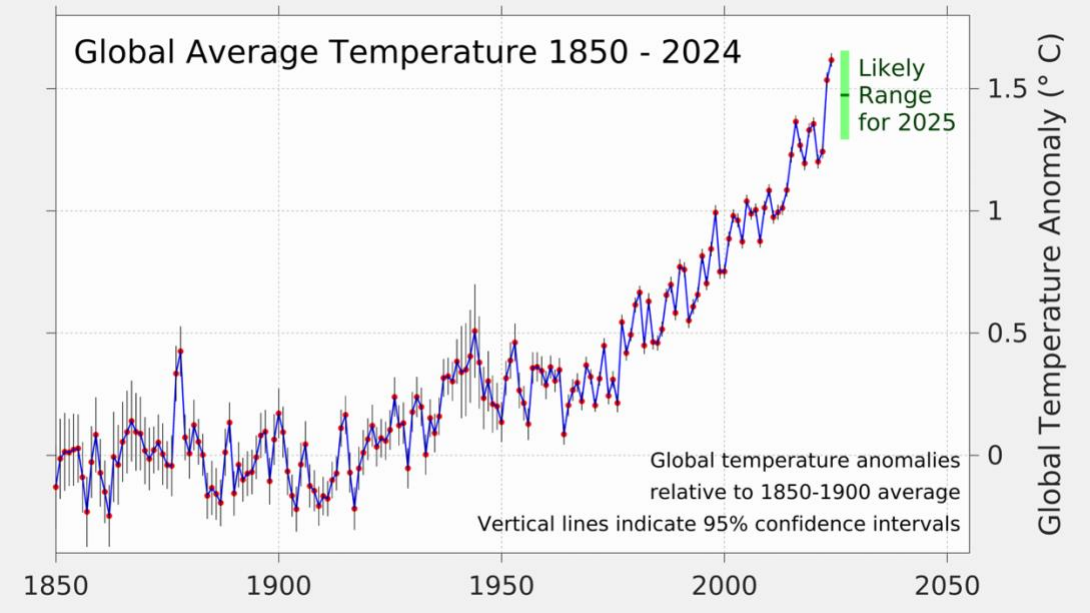


Figure 1-4: Global Average Temperature from 1850 to 2024.
Source: https://berkeleyearth.org/global-temperature-report-for-2024/

As Figure 1-4 above illustrates, the global average temperature increased exponentially from the beginning of the 20th century. According to Berkeley Earth's analysis, the average global temperature for 2024 was observed to be 1.62 ± 0.06°C (2.91 ± 0.11°F) standing above the mean temperature recorded from 1850 to 1900, a timeframe often used as pre-industrial baseline for global temperatures targets. This indicates an increase of approximately 0.08°C (0.14°F) surpassing the highest record of temperature noted in 2023.

As a result of this data, the year 2024 is confirmed to be the warmest year to have been recorded by using thermometer measurements, exceeding all the temperatures observed in the previous years. Moreover, based on the data disclosed by Berkeley Earth, the year 2022 also exhibited the highest temperature increase since the 1870s.

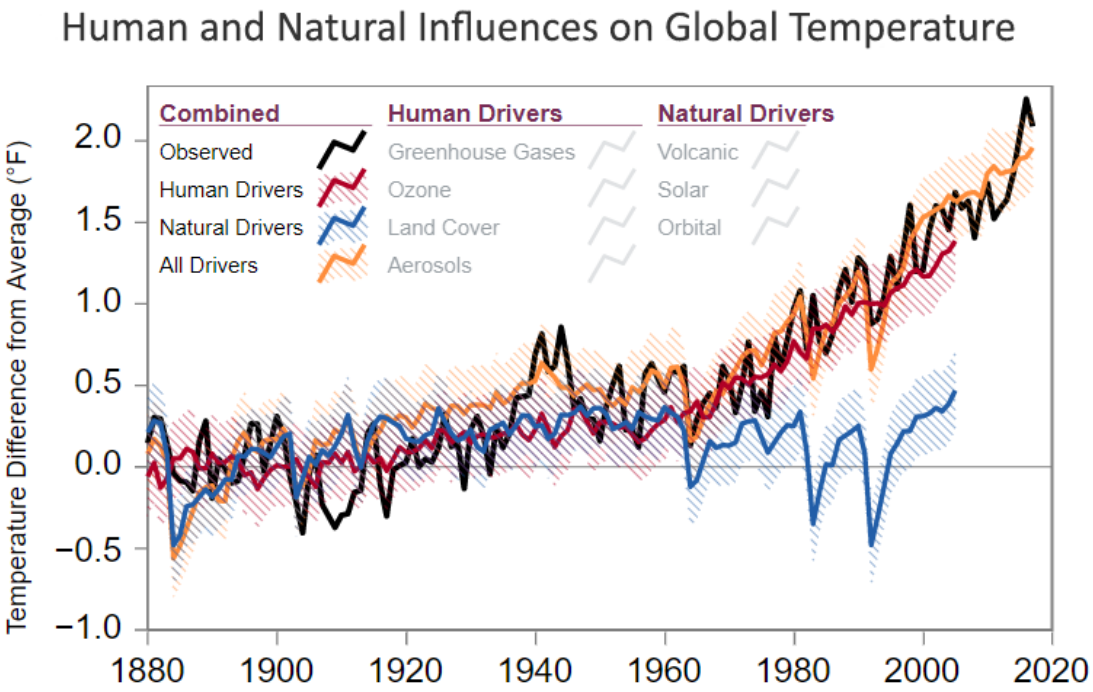


Figure 1-5: Human and Natural Influences on Global Temperature. Source: U.S. Global Change Research Program, Fourth National Climate Assessment,Chapter 2: Our Changing Climate 2018

According to Figure 1-5, the impact of both activities and natural elements on the global temperature patterns from 1880 to 2020 is depicted. The recorded shifts in temperature are closely related to human influenced factors like greenhouse gas emissions and changes in ozone levels, as well as alterations in land cover and aerosols. On the other hand, temperature fluctuations caused by occurrences such as volcanic eruptions, solar energy fluctuations, and changes in the Earth's orbit demonstrate less consistency with the documented temperature patterns. The ride in temperatures during the 20th and early 21st centuries cannot be solely attributed to causes alone. With a combined model that considers both natural elements and human activities closely mirroring the temperature data, it is evident that human actions have significantly contributed to the global warming trend.

1.4. Business & Sustainability: Corporate Sustainability

The sustainability topics became significant with the start of the Industrial Revolution in the 18th and 19th century when people began using natural resources more intensively for energy and raw materials. The economic growth at the time was restricted by biological factors because people used organic energy which included human power together with animal power and biomass including wood heat.

When people started using coal as their primary energy source together with the steam engine, they removed restrictions from the pre-industrial era and thus enabled the acceleration of industrial development and economic growth powered by fossil fuels. During the Second Industrial Revolution, advancements in electricity and chemical industry together with combustion engine improvements boosted industrial development but caused more environmental damage. The course of unsustainable development has steepened since the middle part of the twentieth century which led many natural scientists to declare a new geological age, the Anthropocene, characterized by substantial changes people made to planetary operations especially through climate alterations and biodiversity destruction and elevated nitrogen and phosphorus loads.

Business has become an essential component of solving environmental and social challenges since the mid-twentieth century as awareness about sustainability issues has increased. The world's largest corporations drove economic growth which formed deep connections with the three pillars of sustainability environmental, social, and economic aspects and therefore created both the responsibilities and dependencies. A sustainable business is an organisation that positively impacts the economy, society, and environment pillars, striving to achieve the 2030 Agenda and its relative SDGs and promoting an effective transition towards a more sustainable economy. Therefore, becoming a sustainable business requires both inward and outward positive effects, with an economic focus on one side and a broader societal focus on the other. Hence, sustainability can benefit both the internal company and the outside environment, especially in the long term.

The crossing of important environmental thresholds has raised concerns about the possible consequences on global systems and human livelihoods, therefore businesses have to embed sustainability strategies into their operations, either voluntarily or as a result of increasing external challenges. The United Nations Sustainable Development Goals (SDGs) which the General Assembly adopted in 2015 for sustainable global progress by 2030 remained the focus of many corporations during the COVID-19 pandemic disruptions. These goals provide global

business guidance on how to work towards poverty reduction, social justice, environmental conservation, and climate action.

Examples of sustainability in business

In the business sector, sustainability is put into practice by improving energy efficiency using alternative energy and carbon management, investing in infrastructure that reduces GHG emissions and saves natural resources, and by optimising supply chain processes for a circular economy. These include measures like reducing waste, encouraging sustainable use, and increasing resource utilisation. Business organisations are currently giving much attention to risk management and resilience to meet the regulatory requirements and long-term sustainability goals in order to adopt a more sustainable and flexible approach to environmental and social issues. The new direction confirms that corporate sustainability practices deliver twin benefits to businesses since they improve operational efficiency while supporting societal well-being and environmental durability thus proving the need for a new economic model.

The value of sustainability in business

We are operating in a world full of uncertainties. Climate change, shrinking natural resources, and the increasing energy and food demands have affected business operations and supply chains in ways that have not been seen before. This calls for both private and public entities to change their operational frameworks fundamentally. To become successful sustainable businesses, one must achieve new high levels of resilience and agility through responsible practices that protect the planet. Sustainability should be fundamental to business strategies and operational activities because it is both morally right and makes financial sense to do so: the younger workforce prefers to work for companies whose missions prioritise environmental protection during their job searches because 71% of job seekers feel companies focused on environmental sustainability make better employers. Consumers are prepared to pay higher prices for products from companies dedicated to environmental responsibility because 80% view sustainability as critical to their purchasing decisions. Customers and stakeholders are demanding companies to be more accountable for climate change action as well as other corporate responsibilities. Leading economies are creating or refining corporate disclosure requirements for environmental performance, which forces businesses to lower their greenhouse gas emissions. The rise of ESG investment standards, together with sustainable financial investing, shows that sustainable businesses attract a rising number of responsible investors. According to current projections, ESG investments are expected to surpass USD 53

trillion by 2025, at which point they will make up more than a third of all global assets. Companies need to pursue decarbonisation together with strict adherence to environmental regulatory standards and deadlines and improved resource utilization in order to protect our planet and our future. Organisations at the forefront of sustainable business strategies implement innovative business models to gain customer loyalty while identifying cost reduction opportunities.

Benefits of a Sustainable Business Model

The companies that integrate sustainability at their core have gained multiple advantages across different areas (see Figure 1-6). These involve:

The first major advantage businesses gain through sustainability efforts is competitive market positioning because customers regularly choose companies that protect the environment. A recent market study revealed that 55% of customers base their brand choices on environmental responsibility because a strong sustainability record draws ethically conscious customers.

Investor interest in sustainable businesses has recently increased because four out of five individual investors plan to include sustainability and social responsibility factors in their investment choices, according to a 2021 source.

Companies that prioritize sustainability now benefit from the growing financial advantages. Businesses should view compliance with developing government policies as a fundamental driver alongside regulatory requirements. Businesses that actively adopt sustainable practices now take advantage of future compliance requirements as governments worldwide expand corporate sustainability regulations and Sustainable Development Goals (SDGs). Companies that adopt these strategies early can measure and benchmark their ESG performance systematically, which leads to long-term regulatory alignment. The sustainability approach fortifies transformative investments since it strengthens business durability while preparing organisations for future market problems and fresh market possibilities post COVID-19 pandemic.

Organisations that prioritise sustainability achieve superior talent management because their employees desire meaningful work environments that integrate corporate social responsibility concerns. A solid sustainability commitment creates an employer brand that attracts and keeps most desiring employees. Sustainable companies obtain a strong advantage in attracting and retaining staff because employees focus on finding purposeful work environments that emphasize corporate social responsibility. Through sustainability commitments, organisations create an attractive workplace that enables successful employee and recruitment practices.

Sustainable business approaches generate immediate financial advantages because they build long-term revenue growth together with financial stability. Businesses that achieve resource efficiency through waste minimisation reduce their operational costs while enhancing their financial performance over time. Even though sustainability initiative setup requires substantial funding at first, companies find that prolonged market leadership and improved profitability outcomes confirm these expenses as worthwhile investments.

Figure 1-6: The benefits of sustainable business.
Source: https://medium.com/@Smartjeffery/building-a-sustainable-business-a-path-to-long-term-success-5f84bf83f8e0

The Figure 1-6 above shows, the circular diagram illustrates continuous benefits that feed into one another, it highlights the benefits of sustainable business, suggesting that these benefits reinforce one another.

Core Areas of Corporate Sustainability

There are five essential areas to concentrate on to create a resilient path forward:

Climate risk management and ESG reporting

Natural disasters have produced their highest impact during the last ten years. Companies need to develop scalable and replicable systems to handle climate change effects, which create severe weather events. Develop solutions that combine multiple data types (proprietary, third-party, geospatial, weather and IoT data) with advanced analytics to prepare systems against disruptions. Preparing for major weather events will support lasting business growth and maintain continuity of operations. Companies should reduce operational expenses while they work to simplify ESG compliance and reporting requirements.

Development of resilient infrastructure and intelligent operations

Global challenges require businesses to design and operate their infrastructure resilience due to climate change and environmental degradation alongside security and privacy issues and limited resources. Organizations that deploy intelligent asset management and predictive maintenance and monitoring extend asset lifespans while reducing downtime and maintenance costs and optimizing maintenance and repair inventories and lowering CO_2 emissions and reducing waste. This method will help businesses reach their ESG goals while still generating profits.

Sustainable supply chains and circularity

Supply chain leaders should implement circular economy strategies that support product reuse because customers increasingly demand product origin information. Blockchain technology provides enhanced supply chain transparency by enabling real-time inventory updates and performance analytics to build trust while ensuring product authenticity throughout its journey from origin to consumption and reducing both waste and costs. Advanced AI systems must be implemented to optimize fulfilment and delivery networks, which will reduce logistics-related emissions, while companies need to develop product provenance systems to manage Scope 3 emissions.

Electrification, energy, and emissions reduction

To achieve large scale clean electrification, leaders must work together to redefine how electrical systems operate and function within a net-zero greenhouse gas emissions economy. To decarbonise the grid, improve efficiency, safety, reliability, and resilience through intelligent asset management in energy and utility sectors to propel the decarbonisation shift. Through the adoption of smart metering systems, you can enhance resource usage tracking which leads to optimising the performance of critical assets, decreasing expenses, and providing better services through automated systems.

Sustainability strategy

Large-scale operational sustainability requires businesses to integrate environmental responsibility into their fundamental operational strategies. Through this approach, businesses create novel models and platforms that serve sustainability objectives, boost operational performance, meet regulatory requirements, uncover innovative possibilities, and build superior customer value while establishing competitive market positions.

Complexities with sustainability in business

The transition to a truly sustainable business model has several key barriers that organisations must address:

Customer readiness

Even though public perceptions and attitudes toward sustainability are changing, businesses must align their transition to sustainable practices when their customers are ready. Businesses must keep pace with developing sustainability trends but also must not lead consumers by moving too aggressively beyond their demand since this could lead to financial dangers. A successful transition requires a detailed knowledge of what consumers expect, along with partnerships with key partners who bring the needed relationships and ecosystems to support the sustainability transition.

Financial Constraints

The most critical challenge in adopting sustainable business practices involves the substantial initial financial investment required. At first glance, sustaining traditional operations seems more economical than implementing sustainable practices which may discourage firms from adopting these initiatives for the short term. Most organisations demand help to justify their investment expenses because their data show long-term financial advantages and operational resilience from sustainability exceed short-term financial savings.

Systemic Inertia

Sustainability stands as an important priority, yet businesses consistently prioritise faster financial goals over environmental considerations. Companies generally develop strategic plans that extend over decade-long horizons, which prevents them from committing to sustainability goals aimed at achieving 2050 since these goals fail to trigger immediate action. Building an environment that promotes sustainability as an immediate strategic opportunity instead of a distant obligation remains essential to surpass organisational inertia. Companies should convert sustainability risks into business opportunities so they can incorporate sustainable actions into their present strategic initiatives instead of postponing them.

Deficiency in tools, insights, and expertise

The absence of sufficient resources, analytical insights, and specialised knowledge is a major challenge in developing a comprehensive corporate sustainability vision, strategy, and framework. Lack of readiness can be a problem for companies looking to embrace practices or come up with a solid plan of action. The world of sustainability is getting more complicated. The strategies needed to tackle new challenges are getting complex as well. In order to foster a sustainable future, businesses have to develop a network of innovation driven partnerships that will enable transformation and ensure long term environmental and social responsibility.

A prospective outlook on sustainability in business

The business world is adopting sustainability as its fundamental transformation driver, which defines competitive market conditions and prolonged organisational survival. The organisations that develop core strategies based on sustainability while leveraging technology and building cross-sector partnerships will create the best foundation to navigate a rapidly changing worldwide business environment. Sustainability will transform business opportunities into new markets while reshaping industry standards and leadership approaches because consumer expectations align with changing regulatory frameworks and digital innovations.

The integration of information, with cutting edge technologies like artificial intelligent and blockchain has revolutionised how companies approach decision making processes in the corporate world. Nowadays, businesses have the ability to assess risks related to climate change while also enhancing resource efficiency and supporting initiatives for reducing carbon emissions resulting in more eco supply chains. Enterprises are urged to adjust their strategies proactively as sustainability becomes a driving force, in the market to stay competitive. Firms that invest in sustainability initiatives driven by data will bolster their resilience, contributing to global economic sustainability and fairness.

2. Aviation Industry and Sustainability

The aviation industry is an industry with the fastest rate of growth worldwide, establishing connections between people from one country to another on an international scale, enabling global economic growth, and supporting around 11.6 million direct job positions worldwide and approximately 20.4 million indirect jobs (ATAG, 2023), determining its fundamental role for today's society as air travel connects markets by scheduling flights from and to multiple destinations worldwide, facilitates international trade is a key player in the global economy and supports the tourism industry, facilitating social growth.

Despite its economic advantages, air transport involves some costs at the expense of our planet and climate. In particular, air traffic contributes to the release of an extensive and increasing amount of GHG emissions, ranging from the usual CO_2 to other greenhouse gases (e.g., H_2O, NO_x, SO_2) and to the peculiar phenomenon of contrails, contributing substantially to global warming. In 2023, worldwide flights were responsible for emitting 882 million tonnes of global CO_2 (ATAG, 2023). Furthermore, aviation industry is accountable for other environmental issues, such as poor air quality and noise pollution due to aircraft engine emitted noise and GHG emissions.

Air transport emits around 2.5% of the total CO_2 emissions from energy systems (IEA, 2023) or 4% when non-CO_2 are also included (H. Ritchie, 2024) and the growth rate is higher than in other transport sectors because of the base of air transport demand that grew back rapidly from the pandemic (International Energy Agency, 2022; World Energy Outlook 2022, IEA). The ITF has pointed out that, with no technological and policy changes, aviation CO_2 emissions are likely to rise by 2.5 times by 2050 (ITF, 2021). Like other companies, airlines are aware of the climate crisis and the increasing concern of the shareholders and have taken some measures to address it. They embrace sustainable principles and comply with the Non-Financial Reporting Directive (NFRD) and the Corporate Sustainability Reporting Directive (CSRD). Additionally, they are incorporating industry specific sustainability standards from the Sustainability Accounting Sustainability Board (SASB) which are related to airline industry to guarantee accurate reporting.

The following commitment to sustainability reflects the industry's recognition of stakeholders' role in shaping its future. Taking into consideration the air travel rebirth after the COVID-19 pandemic and the critical impact of emissions released by flights, organisations and policymakers initiated to adopt more efficient solutions to mitigate climate change to alter GHG

trajectories, both from a technical (such as aircraft structure and flight routes) and regulatory (such as carbon offsetting programs) perspective.

This section explores the broad aviation sector, contrasting it with the airline industry dimension, analysing its aspects and features, and then considering its impacts on climate change and the relative environmental concerns. Lastly, it analyses how airlines comply with sustainability via different practices, using SAF and other alternatives to conventional jet fuel.

2.1. Introduction to Aviation Industry

The aviation industry has come along days ago since the first flight of Wright Brothers in 1903. Solely, in 2024 approximately 9.5 billion passengers took to the skies. Due to the emergence of COVID-19, it saw a significant decrease in scheduled flight services.

Nevertheless, the aviation industry is an interesting, dynamic, and relevant industry; it plays a crucial role in realising substantial economic growth and development since it is one of the most important industries in terms of growth, enabling connections across different countries. Air transport pertains to the aviation industry, which includes all the aspects of air travel and the relative activities addressed to its facilitation.

As mentioned previously, the aviation sector is among the fastest-growing industries worldwide, supporting the global economy: Enabling $4.1 trillion (3.9% share) (IATA, 2024) in global GDP.

The following sector includes several actors, such as air traffic control and airports (according to ATAG there are 4,072 airports with scheduled commercial flights in the world), a wide range of airline industries, aircraft manufacturing companies (e.g., Boing and Airbus), research companies, military aviation, and several others. Despite, the presence of many players in this industry, the International Civil Aviation Organization (ICAO) categorises the aviation sector into three distinct segments:

1. Commercial Air Transport

This sector comprises aircraft operations for all the operations related to the public transport of passengers, cargo, or mail. The primary feature to link these activities is their capital need to finance flights for passengers and cargo. The commercial sector of the aviation industry is highly competitive. In 2024, an estimated of 5 billion passengers utilised airlines for business and tourism travel (IATA, 2024), enabling people to travel across different countries quickly.

The most relevant players in commercial aviation are airlines, which are entitled to offer public transport services for various routes. These airlines are distinguished into three main categories based on their consumer target and business model:

- legacy carriers or network airlines,
- low-cost airlines (or low-cost carriers, LCCs) and
- ultra-low-cost carriers (ULCCs).

2. General Aviation

General aviation comprises all civil aviation operations different from commercial air transport and aerial work, including civilian non-commercial flights; general aviation operations include flight training, corporate and business flights, private flights, and personal travel.

3. Aerial Work

According to International Civil Aviation Organization (ICAO), aerial work refers to aircraft operations carried out for specialised services, such as emergency flight, agriculture, aerial advertisement, military, observation, and search and rescue and many other operations.

In the end, aviation provides the only way to transport people and materials safely and quickly to and from locations around the world. To simplify this, the aviation industry employs around 86.5 million individuals. In the meanwhile, the global aviation industry's total global market worth is $762.8 billion (Statista, 2023), and is projected to reach $1.1 trillion by 2030.

2.1.1. Aviation Industry vs. Airline Industry

As described in the previous paragraph, three distinct segments of air transport belong to the aviation sector, according to ICAO: commercial air transport, general aviation, and aerial work. The aviation industry is a broader term that encompasses the entire field of air travel, including all aviation businesses and services. The main components in the aviation industry are manufacturing, design, operation, maintenance, air traffic control, airport operations and regulatory bodies of the aircraft. However, taking in consideration the airlines' context, we are dealing with commercial aviation that offers air transport services for passengers and goods, hence, it is a subset of the aviation industry since it is focused mainly on the transportation of

people and cargo. The primary players in the airline industry are: legacy carriers (e.g., ITA Airways, KLM, Lufthansa), cargo airlines (e.g., DHL, Poste Italiane, UPS), charter services (private flight) and low-cost carriers (e.g., Ryanair, Wizz Air, Vueling).

The revenue flows in the aviation industry are generated by manufacturing, maintenance services, air traffic operations, and airport management, while the airlines primarily earn revenue from ticket sales and cargo services.

In conclusion, these distinctions highlight and contrast the two different terms, while the airline industry is a vital branch of the aviation ecosystem, the aviation industry incorporates numerous activities and stakeholders.

2.2. The Impact on Climate Change

Climate change is one of the major global challenges of the 21st century, as mentioned in the previous chapter. Just recall this year's hot summer, heat waves, lack of precipitation, stuffy weather that can also bring health problems (see Figure 2-1). Climate change is caused by the production of greenhouse gases, while the Intergovernmental Panel on Climate Change (IPCC) reported that the anthropogenic influence is 95%. Countries have addressed this challenge employing measures and international agreements aimed at reducing greenhouse gas emissions. In 1992, the United Nations Framework Convention on Climate Change and later in 1997, the Kyoto Protocol marked important milestones; countries joined those treaties and protocols for international cooperation in addressing climate change concerns. In 2015 was held the "Paris Agreement" by UNFCCC, with the effort of limiting the rise of global average temperature below 2°C above pre-industrial levels was formulated, with an additional effort to restrict the temperature rise to 1.5 °C. Aviation sector's contribution to climate change gained relevance as a topic with the release of a special report on "Aviation and the Global Atmosphere" in the 1990s. This is because for many years, the International Civil Aviation Organization has been identifying different measures that can be taken to address the impact of international aviation on global warming. Technical options for more fuel-efficient aircraft and the potentials of renewable fuels have been extensively studied globally. Numerous initiatives have been established to foster research and development; for example, the European research program "Clean Sky", which also investigates other environmental concerns like noise reduction and air quality. Large airlines publish sustainability reports, explaining their initiatives to limit CO_2 and other emissions. The issue is made more complex because it is not only carbon emissions

which lead to global warming, but also other gases, such as nitrous oxides, that contribute to the problem. Carbon emissions may be responsible for only about a third of the overall problem. The following industry is one of the major players in the globalisation and development of the world's economy but also raises significant ecological issues. As Aviation Benefits Beyond Borders reported, air transport generated approximately 882 million metric tonnes of carbon dioxide (CO_2) in 2023, which is about 2.05% of the 57.1 gigatons of CO_2 produced by human activities in the same year, the following percentage includes the emission for each passenger 101g per Km, instead in cruising speed 92kg CO_2 per passenger.

Despite, the average annual traffic growth was 4.5%, emission growth was limited to about half of this rate. This accomplishment has been possible by major investments in new technology, and the efforts to adopt improved operating procedures and infrastructure measures at all levels. The main sources of emissions from aviation are essentially aircraft operations (e.g., taking off and landing) and the burning of fossil fuels. Air traffic volume has an impact on parameters, among others, that determine the quantity of emissions; the exponential growth in this sector has been one of the many issues concerning the environmental impact of aviation. The increase in the demand for air travel stems from the low-cost airlines' pricing policy, which has reshaped air transportation, making it more affordable to a vast majority of people, leading to an increment of the emissions. Also, it is necessary to mention the boost granted to this industry from globalisation, increasing the frequency of air travel for either work or pleasure purposes. Aircraft emissions are not only the source of greenhouse gases in the atmosphere but also affect atmospheric composition through the emission of gases and aerosols (see Figure 2-2). These emissions cause the production of contrails that affect natural cloud types and therefore climate. Since the aviation sector is expanding very fast, fuel consumption and carbon emissions are expected to keep increasing in the future. Accordingly, the growth in aviation demand is predicted to further amplify the negative environmental impacts that will lead to increased warming of the Earth's surface and contribute to climate change.

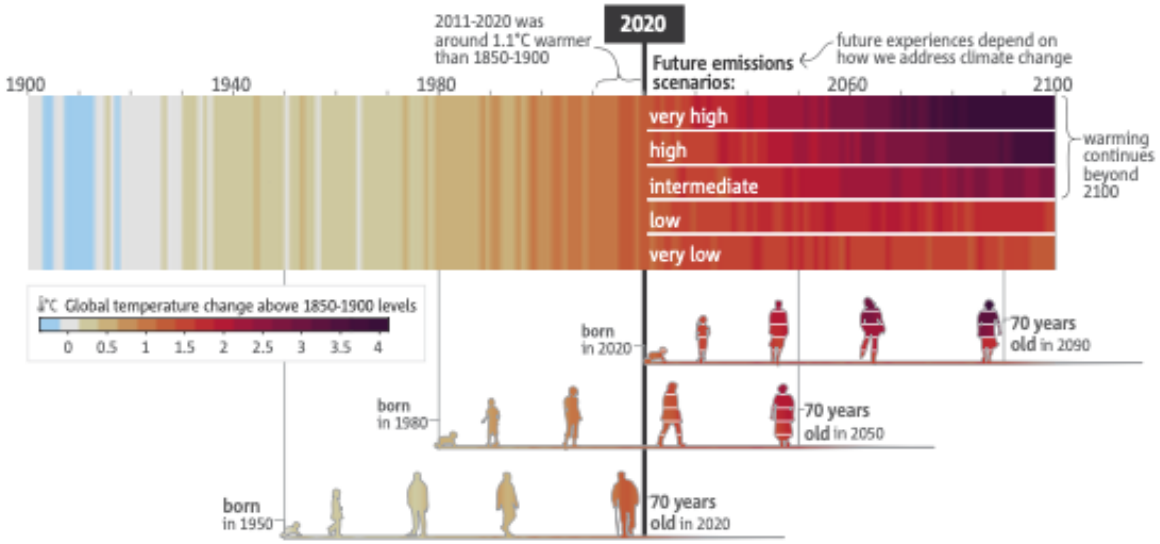


Figure 2-1: Future warming scenarios in the upcoming years.
Source: European Environmental Report 2025

The chart above presents changes in temperatures between 1900 and 2100 while emphasising warming patterns and future predictions linked to various emission scenarios. It demonstrates the escalating warmth, over the years and how forthcoming generations environmental encounters will be influenced by efforts to reduce emissions. The timeline also reflects people born in current years and the expected climate conditions they might face at 70 years old.

As reported in Figure 2-2, the aircraft engines emit substances after the fuel combustion that can potentially impact climate change and welfare loss. The emissions involve elements such as carbon dioxide (CO_2), water vapor (H_2O), hydrocarbons (HC), carbon monoxide (CO), nitrogen oxides (NO_x or NO + NO_2), sulphur oxides (SO_x) and non-volatile black carbon (BC or soot). The mentioned substances undergo complex interactions among themselves and with the changing background atmosphere.

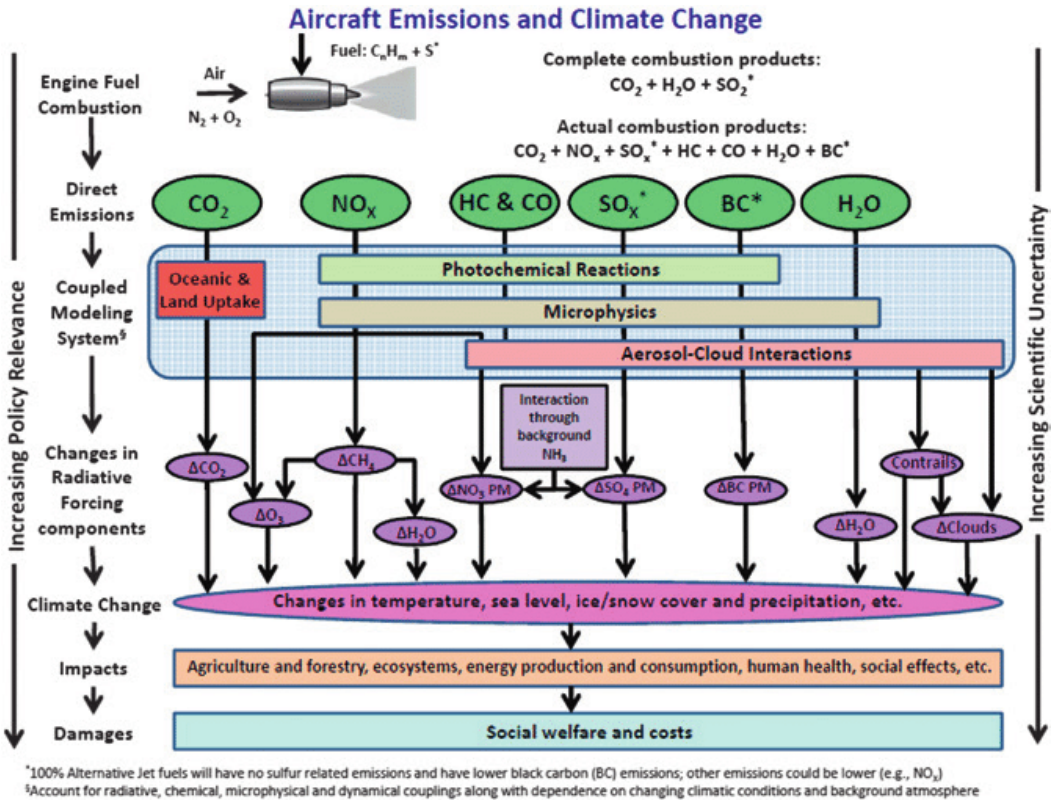


Figure 2-2: Aircraft Emissions and Climate change.
Source: https://www.researchgate.net/figure/Schematic-representation-of-emissions-from-aircraft-combustion-and-their-potential_fig1_312193345

As Figure 2-3 below shows, aviation represents 2.5% of the share in the total human-induced CO_2 emissions in 2023 was due to the burning of 279 million tonnes (348.75 billion liters) of aircraft fuel. This is approximately the same power required to run the servers and transmission cables of the internet. In comparison, road transport contributes 11%. The largest source of human-induced CO_2 emissions is the power industry (26%).

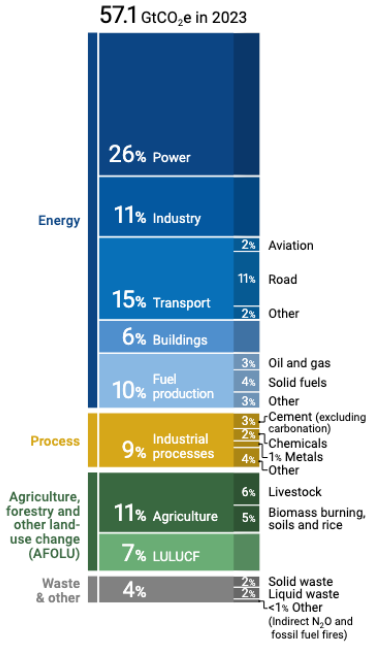


Figure 2-3: Share of aviation in total GHG emissions.
Source: UN environmental programme Emissions Gap Report 2024

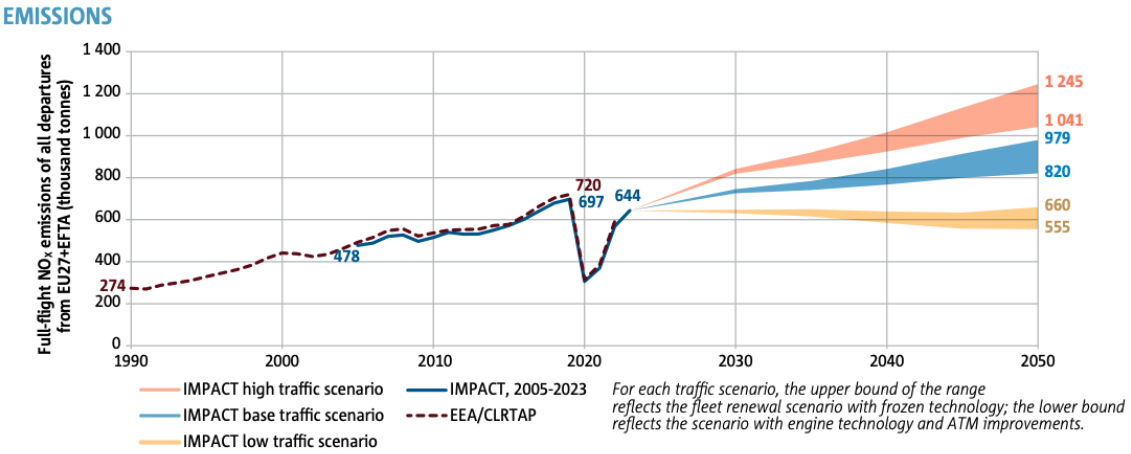
Aviation is an efficient means of long-distance transport, operating in many places more efficiently than the alternatives, such as road and even rail. For some travel, there is simply no practical alternative to flying around 80% of aviation CO_2 emissions are produced from flights greater than 1,500 kilometres.

According to a recent analysis, aviation is the preferred mode of transport for most tourists: in 2023, 58% of international tourists travelled to their destinations by air, compared to 35.8% by road, 4.3% by water and 1.9% by rail.

Other greenhouse gases

Recalling the emission release in the air, CO_2 is not the only greenhouse gas emitted by aircraft. Exhaust fumes from aircraft engines are made up of 7% to 8% CO_2 and water vapour, around 0.03% nitrogen oxides, unburned hydrocarbons, carbon monoxide and sulphur oxides, traces of the hydroxyl family and nitrogen compounds and small amounts of soot particles (although the industry has almost eliminated soot emissions over the past few decades). Between 91.5% and 92.5% of aircraft engine exhaust is normal atmospheric oxygen and nitrogen. The water vapour trails (contrails) created by aircraft also have an impact.

The Figure 2-4 illustrates full-flight emissions NO_x from all departures in the EU27+EFTA region from 1990 to projections in 2050 under high, base, and low traffic scenarios. The table below, shows a summary of CO_2 emissions. NO_x emission, and the average fuel consumption for the selected years.



Indicator[7]	Units	2005	2019	2023	2030
Full-flight CO_2 emissions[8]	million tonnes	109	147	133	144
Full-flight 'net' CO_2 emissions[9]	million tonnes	109	114	108	139
Full flight NO_x emissions[8]	thousand tonnes	478	697	644	726
Average fuel consumption[8]	litres fuel per 100 passenger kilometre	4.8	3.5	3.3	2.9

[7] All departures from EU27+EFTA

[8] 2030 value is for the base traffic scenario with technology and operational improvements.

[9] 2030 value is for the base traffic scenario with technology and operational improvements and sustainable aviation fuels. 2019 and 2023 values include emissions reductions from market-based measures.

Figure 2-4: Full-flight NO_x emissions of all departures from EU27+EFTA. Source: European Aviation Environmental Report 2025

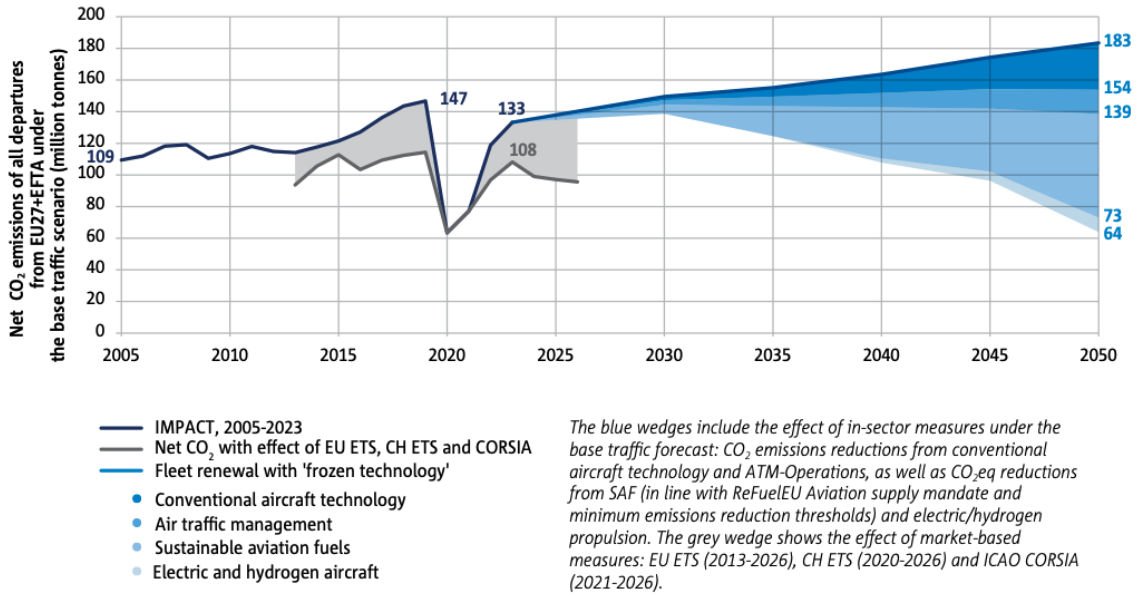


Figure 2-5: Net CO2 emissions of all departures from EU27+EFTA.
Source: European Aviation Environmental Report 2025

The Figure 2-5 displays, the Net CO_2 emissions from all departures in the European Union nations from 1990 to projections in 2050.

2.2.1. Air quality

Beside climate change effects, aircraft engine emissions can influence and contribute negatively to the local air quality, increasing air pollution. Air pollution is one of Europe's largest risks, since it has an impact on the population's health and well-being, causing premature death, cardiovascular, respiratory disease, and lung cancer. Other impacts on human beings are arising, such as mental health and diabetes. In the last decade, The European Union Ambient Air Quality Directives have strived to reduce overall emissions of air pollutants, contributing through different policies to improving air quality (e.g., Directive 2008/50/EC). The following directive sets regulatory threshold for some air pollutants in the air, namely nitrogen dioxide (NO_2), ozone (O_3), heavy metals and sulphur dioxide (SO_2).

Nevertheless, despite numerous directives, the concentration of air pollutants in the air stemming from air travel is still increasing within European Union nations. At the end of 2024,

the EU Ambient Air Quality Directive was revised and then adopted, aiming to set 2030 EU air quality standards aligning with recommendations from the World Health Organization in order to mitigate air quality impacts on humans' health.

The impact of aviation's on-air quality

Aircraft operations are one of the primary sources of air pollution in the surrounding area of the airports; nevertheless, air quality is also impacted by emissions from ground support equipment, surface access road transport and airport on-site energy generation.

Aircraft engines, similar to other vehicle engines operating through fossil fuel combustion, emit equivalent pollutants, mainly nitrogen oxides (NO_x) produced by aircraft engines during take-off, particular matter (PM), volatile organic compounds (VOC), sulphur dioxide (SO_2) generated by aircraft engines when burning fuel containing sulphur and carbon monoxide (CO). Moreover, research reported that aircraft emissions may contribute to increased ozone (O_3) levels resulting from the chemical reaction of oxidization between nitrogen oxides (NO_x) and carbon monoxide (CO) or in the presence of sunlight and warm conditions by volatile organic compounds (VOC) (EASA, 2018). These emissions originate from aircraft operations at lower altitudes, such as during takeoff, and some from ground support activities such as landing gear and control surface movement, surface access road transport, and many others. As a result, it leads to levels of pollutants near airports, impacting nearby locations' local air quality.

In addition to the emissions of the mentioned substances into the air, aircraft engines emit ultrafine particles (UPF) across a wide range of operating modes. The following UPF, are classified as subsets of particular matter. According to various research, exposure to ultrafine particles can impact respiratory and cardiovascular systems, as well as contribute to long-term effects on premature mortality, since UPF can penetrate the bloodstream and transport toxic substances in the human body.

Influence on Local Air Quality

The current directives from the European Union do not require the monitoring of air quality in the surrounding areas of airports, instead assessments are typically done in areas to reflect the levels of pollutants affecting the population's exposure. The World Health Organization (WHO) has not set guidelines for monitoring Ultrafine Particles (UFP), instead it provided recommendations for their control and management methods.

A study from 2018 examined the level of air pollution in six cities with large airports. Paris Charles de Gaulle Airport, Amsterdam Schiphol Airport, Frankfurt am Main Airport, Munich

Airport, Brussels Zaventem Airport and London Heathrow Airport. It was found that in urban areas, air travel accounts for approximately 2.5% of the annual levels of nitrogen dioxide (NO_2) in the air and roughly 1.8% of sulphur dioxide (SO_2). Moreover, at airport locations, the levels of these pollutants were significantly elevated with NO_2 at 38%, SO_2 at 45%, PM_{10} at 0.5% and $PM_{2.5}$ at 0.3%.

Living areas near airports may be exposed to elevated NO_2 levels due to aircraft operations. An analysis demonstrated that 55% of NO_2 levels at an airport were caused by aircraft discharges, reaching 17 μg/m³ which is higher than the WHO's recommended limit of 10 μg/m³. Instead, as you move farther away from the surrounding airports, the percentage decreases dramatically by 63% for every mile. The drop in emissions is meant to be caused by air dispersion effects and the city's sources like traffic and industries among others which becomes more notable.

Recently, the European Environment Information and Observation Network (EIONET) required information on air quality near airports. Therefore, multiple EU Member States conducted studies on air quality. It was done for airports in Austria, in Brussels (Belgium), in Copenhagen (Denmark), and in Helsinki (Finland). The aims of these studies regard (UFP) conducted analyses on regulated pollutants, such as NO_2 and PM_{10}. Furthermore, the upcoming amendments to the Ambient Air Quality Directive, recognise airports as areas where individuals may be exposed to pollutants over long periods. Therefore, the directive highlights the necessity of monitoring UFP levels at airports in order to evaluate the air quality.

2.2.2. Noise pollution

Noise is a primary concern in aviation. It can have multiple negative effects on human health and well-being for those living in the surroundings of airports, including community annoyance, sleep disturbance, cardiovascular diseases (e.g., worsening blood vessels and heart functions), mental health problems (e.g., depression) and metabolic problems (e.g., obesity). Although noise production by individual aircraft has become approximately 75% less noisy over the last three decades, thanks to economic and technological development. In contrast, with the increment in air traffic, many EU citizens are still exposed to significant noise disturbance.

The European Community adopted Regulation (EU) No 598/2014 to maintain sustainable aviation, which outlines procedures concerning noise-related operating restrictions. The implemented regulation affects air carriers from EU/non-EU countries. It aligns with international principles on noise management, known as the "Balanced Approach", established,

and recommended by International Civil Aviation Organization (ICAO). The Balanced approach consists of four key elements:

- Setting noise standards leading to making aircraft quieter,
- Implementing a sustainable way to manage land around airports,
- Establishing operational procedures to minimise the noise impact on the surface and
- Imposing operating restrictions.

The EU regulations establish a structured and transparent procedure for introducing operating restrictions, ensuring that decisions are evidence-based and deliver optimal solutions for noise mitigation, safety, capacity, and cost.

Airport Levels Noise in the EU

According to the Environmental Noise Directive (END) countries must create noise maps for airports with more than 50,000 flights a year and for airports in urban areas with over 100,000 residents, whether they are major or minor airports in those places. The maps are used to help create plans to reduce noise levels in the areas. The END sets limits for evaluating area where noise levels reach or surpass L_{den} 55 decibels (dB) during the day and 50 decibels (dB), at night $L_{night.}$ Research has shown that health issues can occur at levels higher than the specified thresholds mentioned earlier in the context of aircraft noise recommendations by WHO Europe, L_{den} 45 (dB) and L_{night} 40 (dB).

Data collected in 2022 regarding noise mapping shows that 2.4 million people are exposed to aircraft noise levels surpassing 55 dB during the day (L_{den}) with 0.7 million individuals experiencing noise levels exceeding 50 dB, at night (L_{night}). When compared to the recommended limits set by WHO Europe, the number of affected populations increases to 14.9 and 5.3 million. It is worth mentioning that the strategic noise maps for 2022 depict conditions from the year when COVID 19 disruptions still had an impact on passenger transport. The data from 50 airports in the EU27+EFTA region for the year-end 2022 reveals that 649,000 people are significantly bothered by prolonged exposure to aircraft noise and roughly 127 000 individuals experience considerable sleep disturbances. According to the threshold set by WHO Europe, these numbers rise to 2.3 million and 680,000 respectively.

Moreover, according to EASA in Europe aircraft noise is linked to an estimated total of 500 cases of heart disease, 200 cases of type 2 diabetes, and around 600 premature deaths. The influence also reaches into the realm of schooling as over 7,900 students could potentially face

challenges in reading skills because of exposure to noise within school premises (see Figure 2-6). In general, the overall health impact associated with aircraft noise is estimated to result in around 19,000 disability-adjusted life years (defined as the sum of years of life lost due to death and years of life lost due to health restrictions).

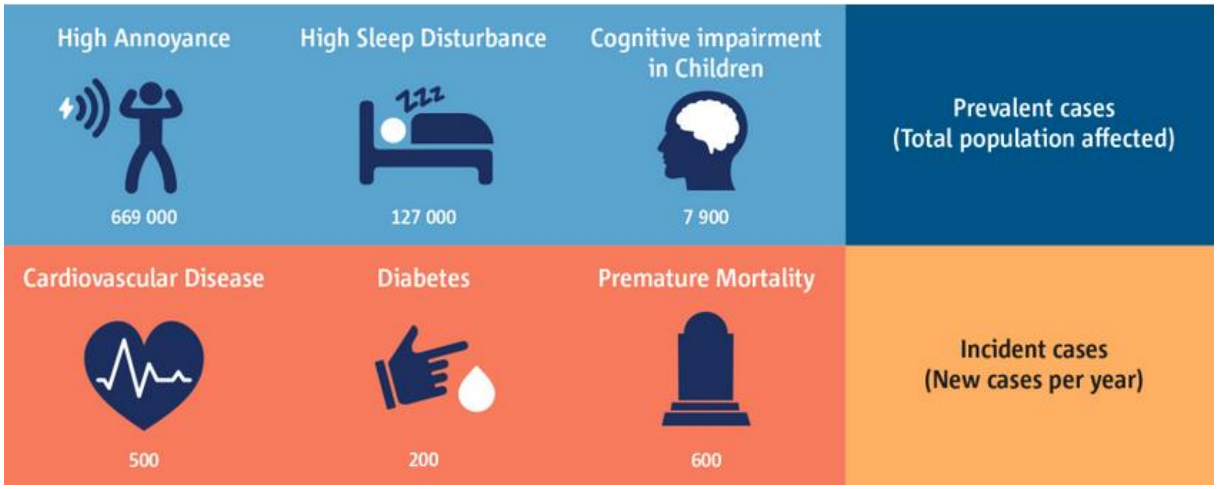


Figure 2-6: Number of individuals affected by exposure to aircraft noise in the EU plus Iceland, Norway, and Switzerland.
Source: European Aviation Environmental Report 2025

2.3. Sustainability in the Aviation Sector

As mentioned in the previous paragraphs, sustainability is a crucial topic across all industries. Especially nowadays with the increase in population and many other issues, where the Earth Overshoot Day is taking place earlier every year. It rises the need for all organisations to implement sustainable initiatives in order to have the lowest impact on the earth; since the aviation industry is contributing as well, most companies are adopting new eco-friendly practices to become sustainable and minimise the industry's environmental impact. With the increase in population, maintaining sustainability in aviation is really challenging due to the increment in demand for air travel, and it's expected to grow in the future decades.

The aviation industry is facing pressure to adopt and find ways to reduce its environmental impact of flying, since most people prefer air travel instead of other modes of transport. The main constraint regards the current aircraft technology, which could be more effective, during the take-off, landing and climb phases. During the outlined phases in a typical flight, planes emit more pollutants. Instead, they are designed to be fuel-efficient mainly at cruising altitudes.

Aviation emissions are generated by fuel combustion, which is a major source of pollution. The remedy to mitigate aircraft emissions is to deploy sustainable aviation fuel (SAF), an alternative to fossil-based jet fuel made from biomass, algae, and household waste, able to cut emissions by up to 80% when compared to fossil jet fuel.

As mentioned before, sustainable aviation fuel (SAF) is an alternative liquid hydrocarbon fuel currently used in commercial aviation, which can replace jet fuel without implementing any modifications to both the aircraft and infrastructure. SAF comprises the same hydrocarbons as normal fossil-based kerosene. The main difference lies in the origin of hydrocarbons derived from a more sustainable source. Today, SAF is blended with different levels of conventional kerosene with the limits between 10% and 50% SAF to secure compatibility with aircraft, engines, and fueling systems. According to ATAG, commercial flights are allowed to fly with a blend of SAF and conventional fossil-based kerosene. Nevertheless, the international aviation industry is looking forward to reaching net-zero carbon in 2025 (see Figure 2-7 below), making a lot of effort to make commercial flight being permitted to fly with 100% SAF, representing one of the essential tools to meet these goals. Based on what is reported by International Civil Organization, over 360,000 commercial flights have used SAF in 2023 among 40 different airports mainly located in U.S. and Europe.

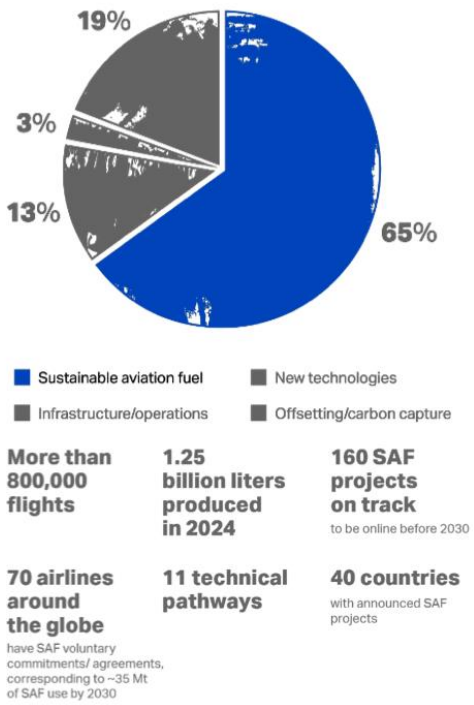


Figure 2-7: Contribution to achieving Net-Zero Carbon in 2050.
Source: International Air Transport Association

The chart above illustrates, the estimation made by International Air Transport Association resulting that SAF may contribute around 65% of the reduction in emissions needed by the international aviation industry to achieve fly net-zero.

Benefits of the adoption of SAF

Sustainable aviation fuel and other renewable hydrocarbon biofuels offer numerous benefits, such as:

- Compatibility with engine and infrastructure: as mentioned previously, the integration of hydrocarbon biofuels does not require any changes to aviation, considering that SAF is blended with conventional kerosene.
- Minimising emissions: according to the U.S. Department of Energy, in contrast with conventional jet fuel, the full use of SAF can potentially reduce green gas emissions by up to 80%.
- More versatility: SAF is a replacement for conventional jet fuel, enabling various products from different feedstocks and production technologies.

Aviation fuel map at EU Airports

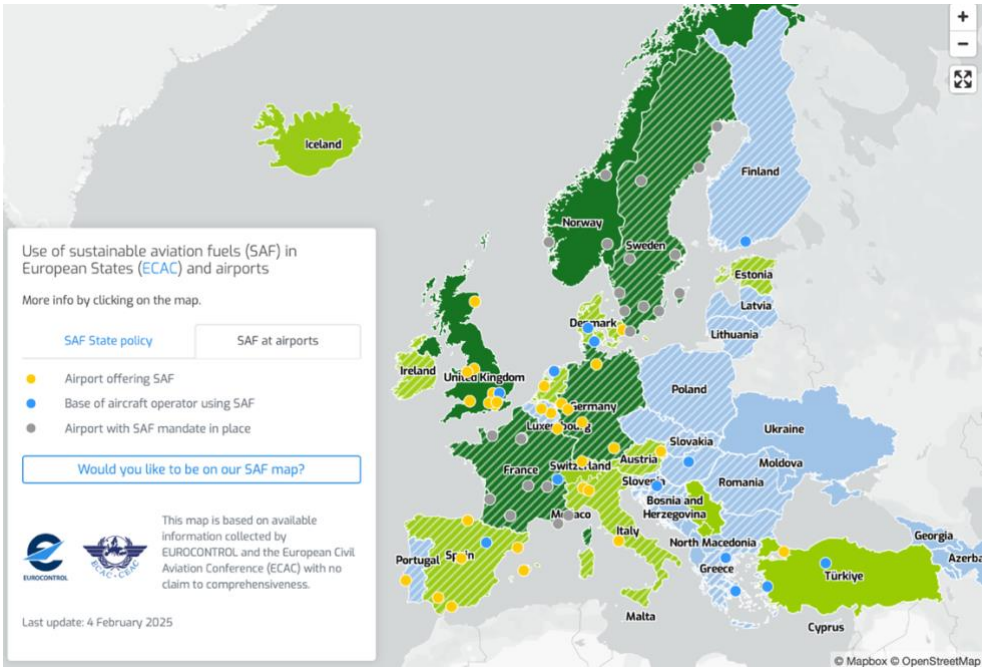


Figure 2-8: European Airports Supplying SAF.
Source: Eurocontrol, https://www.eurocontrol.int/article/sustainable-aviation-fuels-saf-europe-eurocontrol-and-ecac-cooperate-saf-map

2.3.1. SAF Production

SAF can be made from various sustainable feedstocks including used or waste cooking oils and fats, waste mass, municipal solid waste, and many other feedstocks (see Figure 2-9). In order to be qualified as SAF, nowadays CORSIA Sustainability Criteria for CORSIA Eligible Fuels powered by ICAO requires feedstocks to meet two sustainability criteria:

1. Attain a minimum reduction of 10% in net greenhouse gas emissions compared to the baseline life cycle emissions values and
2. Ensure that it's not made from biomass sourced with a significant carbon stock.

There are several methods to produce sustainable aviation fuel (SAF), each with different benefits. These are the primary pathways:

- Hydroprocessing of Esters and Fatty Acids (HEFA)
  HEFA employs oils obtained from plants, animals, and waste products, reshaping them into jet fuel fitting with regular aircraft fuel.

- Fischer-Tropsch (FT) synthesis
  FT synthesis processes waste and energy crops into jet fuel through converting waste materials via a specialised method.

- Alcohol-to-Jet (ATJ) conversion
  ATJ conversion changes ethanol and isobutanol, extracted from plants, into jet fuel. Following these methods accommodates a variety of plant-based materials, leading to a significant step toward fly net-zero by 2050.

These techniques permit the aviation industry to have a wide range of options for producing SAF, each having different benefits and material sources. Thanks to continuous advancements, the aviation industry is making significant progress towards minimising pollution in aviation.

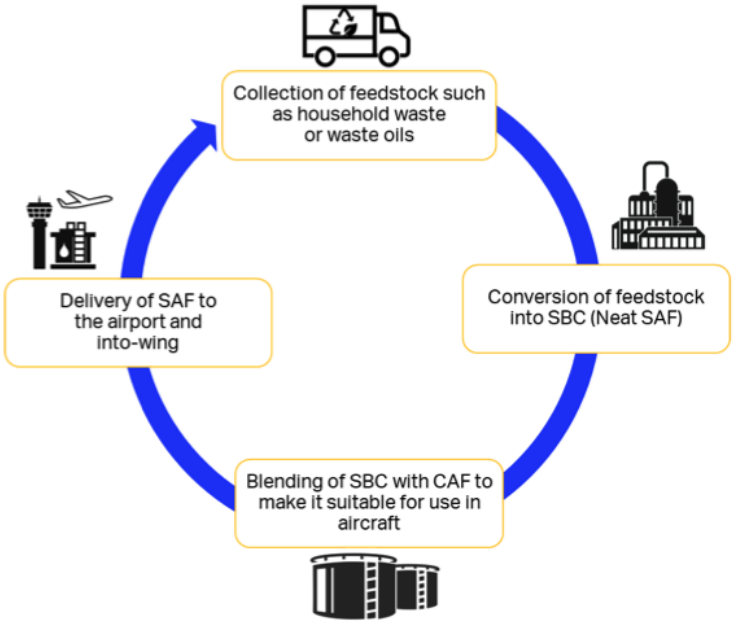


Figure 2-9: SAF's lifecycle.

Source: IATA, https://www.iata.org/contentassets/d13875e9ed784f75bac90f000760e998/saf-handbook.pdf

The current commercial SAF producers are shaping the future of the sustainable aviation industry. The leading commercial producers are:

- World Energy started SAF production in 2016 in Paramount, California. Began to supply SAF at Los Angeles International Airports.
- International producer Neste began supplying SAF to San Francisco International Airport in 2020, then in 2021 and 2022, expanded to other airports in California and Colorado.
- In 2023, Montana Renewables LLC started the production of SAF in partnership with Shell. At present, they are supplying fuel to several airlines.

More new domestic plants are coming in the short-term, reducing the emission of air travel, and creating a sustainable aviation future. These companies show the industry's commitment to contributing to the development and success of a green aviation industry.

2.3.2. Alternative Jet Fuels

Nowadays, the aviation industry uses jet fuels such as Jet A-1, JP-5, and JP-8 (military use). Jet 3 and JP-4 are blended fuel with kerosene-naphtha and kerosene-gasoline. Beside Sustainable Aviation Fuel (SAF), there are other alternative jet fuels that can be used as SAF.

Green Aviation Fuels	
Bio-jet fuels	Biofuels are renewable fuels derived from algae, waste oils, agricultural residues, and biological sources (e.g., plants and organic waste). They are considered a sustainable alternative to fossil fuels, providing a lower carbon footprint by cycling carbon through living organisms.
Electro-jet fuels	Electrofuels are produced from electricity as the primary source of energy through electrolysis with the adoption of captured carbon or nitrogen, creating, for example, methane, kerosene, methanol, hydrogen, and ammonia.
Hydrogen	In recent and past research hydrogen, is considered as an attractive option to conventional jet fuel, as it can be used directly in aircraft, and it has a great supply potential contains around three times the energy content of jet fuel (43.2 MJ/kg vs 120 MJ/kg respectively). It does not produce CO_2 from combustion.
Liquefied methane	Studies and experimental tests have demonstrated that liquefied natural gas is a realistic alternative as aviation fuel. The primary energy component in LNG is methane, which can be produced from both biomass and electrofuels pathways. It has not yet been integrated into normal services and operations due to several challenges in operating LCH_4 aircraft (e.g., LCH_4 fuel tanks are heavier than the usual fuel tank and supply chain infrastructure).
Ammonia	NH_3 is recognized as an adoptable fuel for gas turbines as it possesses a high level of hydrogen (H_2). Hence, mixing ammonia with H_2 or LCH_4, can be adopted as an alternative aviation fuel in low blending or it can also be used for modified aircraft engines and fuel cells as a dual fuel solution.

Table 2-1: Green Aviation Fuels.
Source: European Commission, Alternative fuels used for aviation

3. Wizz Air Business Case

Chapter 3, analyses Europe's greenest low-cost airline, Wizz Air Holdings Plc. The case study has been chosen because of its fastest growing as low-cost airline and its reputation as a pioneer in sustainability initiatives and strategies. In 2023, it was nominated Europe's Leading Low-Cost Airline by World Travel Awards. It has been recognized by CAPA – Centre for Aviation and by the World Finance as the most sustainable airline group of the year in 2024. Recently, Wizz Air was ranked in the top five safest low-cost airlines by airlineratings.com.

CAPA recognises airlines with the CAPA' Environmental Sustainability Award for Excellent solely to those airlines, airports and suppliers who put climate change as a priority in their business. In 2024, Wizz Air won for the third consecutive year the award.
Wizz Air keeps staying at the forefront of aviation for CO_2 intensity reduction, reaching an industry leading performance in the past few years. Beside fleet renewal, Wizz Air has a commitment to operate 10% of its flights with SAF by 2030.
Wizz Air completed in January 2025 a sustainable aviation fuel (SAF) operation trial. According to CAPA it operated more than 50 flights using a blend of SAF and traditional jet fuel.

The World Finance Sustainability Awards celebrate those companies who, during the year, have excelled in their sustainability efforts, acting, and providing solutions for sustainable air travel options. Wizz Air proudly won the Most Sustainable Company by industry in 2024 as the low-cost airline with the lowest carbon emissions in Europe. One of the key drivers of Wizz Air's sustainability success is their commitment to fleet renewal and operating their flights with the latest innovation and technology available in the market. They also have the youngest fleets globally, around four years. That's one point of their sustainable success.
Therefore, consumers choosing to fly with Wizz Air can diminish a passenger's CO_2 emissions by around 50% less compared to flying with traditional network carriers.
In the meantime, waiting for Airbus with zero-emission hydrogen aircraft, which is 20-25 years away from now, SAF is the best solution nowadays besides fleet renewal and investment in operational efficiency. Wizz Air stipulated different agreements with the world's leading SAF producers, and they also made an investment of 5 million pounds in biofuel companies to support developing new technology and embracing innovation. Having said that, the mentioned airline is marking a tremendous change towards sustainable air travel.

3.1. Brief description and History of Wizz Air

It is essential to introduce the case study of this research, which is Wizz Air, to understand why and how it became one of the most sustainable low-cost in Europe. Below, a description of the mentioned airline, as well as its sustainable strategy.

In September 2003, a small team of six people with a wide range of experience and airline experience launched Wizz Air teamed up with József Váradi, a Hungarian entrepreneur who is the current company's Chief Executive Officer. He was the one who began the history of Wizz Air with the ambition of developing an airline able to keep its fares affordable to every traveller as well as being environmentally responsible. Váradi and his partners secured financing through Indigo Partners LLC and a group of European investors in 2003, allowing them to establish Wizz Air in Hungary. The name of this company originates from the word wizard, we all know the meaning of this word. Instead, the logo of Wizz Air is something similar to a thunderclap.

The story of Wizz Air started on May 19, 2004, when its maiden flight took off from Katowice, Poland, to London Luton Airport. The flight was completely booked from the outset; hence, the airline's success was obvious. Wizz Air's expansion throughout the years continued; the airline's network grew in Western Europe, the Middle East, and Africa.

The business strategy of Wizz Air was built on low fares and auxiliary revenue, which was one of the elements that led to its success. Wizz Air offered a basic service and charged passengers for extra luggage, seat selection and onboard food, thus enabled Wizz Air to keep low prices while earning additional money from extra services.

Another crucial aspect in Wizz Air's success was its ability to cost-cutting. The airline flew with a fleet of Airbus A320 and A321 aircraft minimal maintenance costs. In 2020, Wizz Air has continued to grow despite the COVID-19 outbreak than any other carrier. During the crisis, Wizz Air ordered new planes to add to its fleet, known as Airbus A321neo, aiming to cut costs and enhance its environmental performance.

Nowadays, Wizz Air is one of the leading ultra-low-cost airlines in Central and Eastern Europe. The airline has more than 8,000 aviation professionals, operating on 924 routes across Europe and the Middle East, connecting over 190 destinations in 54 countries, flying with the youngest fleets in the world with 208 Airbus A320 and A321. According to Wizz Air's financial report, in the fiscal year 2024, the company revenue was 5.1 billion with an increment of 30.2% from fiscal year 2023 (Wizz Air, 2024). Currently, Wizz Air is a group of four airlines: Wizz Air Hungary (founded in 2003), Wizz Air UK (founded in 2017), Wizz Air Abu Dhabi (founded in 2020) and Wizz Air Malta (founded in 2022).

3.2. Definition of a Low-Cost Airline

Through this thesis, low-cost carriers are mentioned multiple times. As Wizz Air is low-cost airlines, it is relevant to clarify the definition of low-cost airline, in order to understand the terms and conditions of the low-cost airline industry. The first low-cost airline was born in the United States, Southwest Airline, in 1978. It reached a high profit and success with this business model. Afterward, the success of Southwest Airline influenced other American airlines to become low-cost as well. Few years later, as Europe wanted to be able to compete with American airlines, European airlines embraced the low-cost models during the 90s. Over the last years, low-cost airlines have grown exponentially in terms of flight and passengers, covering 34% of flights in Europe in 2024 (Eurocontrol, 2024).

Low-cost airlines are companies that do not offer many traditional passenger services as a part of the fare, instead they offer lower fare at the expense of fewer comfort and service. They recoup the low price of the ticket by charging for a range of extras such as food, seat allocation, priority boarding, luggage.

The main characteristics that distinguish “Legacy airlines” from “Low-cost airline” are that baggage is not provided, meals and drinks are not offered, the use of aircraft that save costs and minimise operational expenses (e.g., A321neo), recruitment of employees with lower wages. Through the mentioned characteristics of a low-cost airline, it is clear how this business model’s works, the main priority is to keep fares low by reducing elements, to both customers and employees. The leading low-cost in Europe in the year 2024 were Aer Lingus, EasyJet, Jet2.com, Norwegian, Ryanair, Vueling and Wizz Air.

3.2.1. Wizz Air’s Business Model

Wizz Air’s business model follows the low-cost carrier model. The reason why Wizz Air can offer the best tariffs is due to their commitment to reduce costs and keep their business model simple and efficient. First and foremost, they eliminated extra free services on board such as in-flight meals and entertainment. They operate through direct flights having solely points to point routes. Wizz Air generates extra revenues through ancillary revenue through extra services not included in the ticket prices. The airline offers direct booking procedures through their website or their app, doing so they avoid expensive intermediaries, such as third-party websites or travel agencies that sell tickets of flight on behalf of the low-cost airline. Moreover, as will be mentioned in the seven reasons why Wizz Air is the greenest choice, the airline does

not offer business class on their aircraft, instead they only have a single class. Another point is its fleet efficiency, Wizz Air operates solely with a young and fuel-efficient fleet of Airbus A320 and A321, operating with a modern fleet Wizz Air can reduce fuel costs and maintenance expenses. In addition, like many other low-cost airlines, Wizz Air mainly operates through primary & more preferred secondary airports. Nevertheless, the choice of the airport has great importance to maintain a low-cost base.

3.3. Wizz Air's Services

Wizz Air as noted earlier has a strong focus on innovation. In January 2007, its Chief Executive Officer received Ernst & Young's 'Brave Innovator' award and he claims that they were at the right place at the right moment. Despite the presence of various low-cost airlines in the market, Wizz Air is doing something different such as being a pioneer in sustainable innovation in the industry meanwhile attempting to provide the lowest fare with the lowest environmental impact. As stated by József Váradi the Wizz Air's objective is to offer travellers an easy and affordable solution compared to other ways of travelling such as car, bus, and rail. Wizz Air is a friendly, enthusiastic, and green airline with an easy and best fare choice for flights to the most popular European destinations.

Wizz Air offers a low-cost fare without sacrificing service quality. They have established a cooperation with Lufthansa and Swedish SAS Technical Services, settling a standard of high quality. As said by Wizz Air CEO József Váradi, offering a low-cost ticket does not need reduce comfort or safety in air travel, as Wizz Air is one of the few airline companies having the youngest fleet with more than 100 aircraft operating in the market, providing to its passengers the best flying experience amongst the low-cost airlines.

It is necessary to mention all the services offered by Wizz Air, with its various alternatives they can satisfy more and more passengers in order to maintain tie its customers to the airline. From the home page of wizzair.com customers can access all Wizz Services:

Wizz Air's service	Description
Airport comfort services	Through this service, Wizz Air offers to its passengers: 1. Security fast track (save time, skip the queues) 2. Exclusive lounge (relax and comfort)
Fare lock	Through this service, Wizz Air offers to its passengers the opportunity to hold a selected flight for 48 hours with the possibility to lock the fare without any passenger names. Nevertheless, this service is only available for bookings created more than seven days prior to the flight
Priority	Through this service, Wizz Air offers to its passengers: • Priority check-in • Priority boarding • Carry-on bag • Trolley bag
Flex	Through this service Wizz Air offers to its passengers the possibility to change the flight up to 3 hours before without a change fee. In case of cancelling their reservation, they get the refund on their Wizz account
Onboard services and magazine	Through this service, Wizz Air offers to its passengers: - Delicious meals and refreshing beverages - Boutique shopping experience (e.g., fragrances and beauty product)
For families	Through this service, Wizz Air offers to its passengers to enjoy a high discount by purchasing a group membership with up to 5 people. Moreover, if the passenger is traveling with a child younger than 2 years old, it is eligible to have free priority boarding
Account	Through this service, Wizz Air offers to its passengers the opportunity to manage bookings and access to the Wizz Account balance
Gift Voucher	Through this service, Wizz Air offers, to its passengers the possibility to make a gift through the purchase of a Wizz Air voucher
Flexible travel partner	Through this service, Wizz Air offers, to its passengers the option to make a flight reservation without adding up to 9 passenger names at the time of booking, giving the opportunity to add the passenger name up to 3 hours before the departure
Auto check-in	Through this service, Wizz Air offers to its passengers to check-in automatically 50 hours before the scheduled departure time
Sitting together	Through this service, Wizz Air offers to its passengers the option to sit together, it is only available for booking with 2 adults
Café and boutique voucher	Through this service, Wizz Air offers to its passengers the option to purchase beside your ticket flight a prepaid voucher which allow the passenger to ensure a shopping experience above the clouds
Mobile app	Through this service, Wizz Air offers to its passengers the possibility to download Wizz Air app in order to exploit as much as possible all the services offered. Such as: • Offline functionality • Save, scan and share • Flight status in real time • Mobile app only discounts

Wizz Air's service	Description
Charter flights	Through this service, Wizz Air offers to its clients the possibility to enjoy a charter unique service entirely customizable for both domestic and international flights, nevertheless the following option is only available for corporate travel, incentive trips, sport teams and holiday group as well
Group booking	Through this service, Wizz Air offers the possibility to book for a group of 16 or more passengers and get a fixed price (one price for all passengers) with flexibility (option to change names and add passengers)

Table 3-1: Primary services offered by Wizz Air.
Source: *wizzair.com*

3.4. Wizz Air's Aims and Sustainable strategy

The focus of this thesis as mentioned previously, is to understand the Wizz Air sustainable performance and strategy. Wizz Air focuses on ESG, presenting on its Sustainability website called 'Wizz Cares' four pillars to contribute to the UN SDGs: 'Environment', 'People', 'Governance', 'Economy'. Wizz Air explains how it wants to be the greenest within the airline industry, as environmental responsibility is essential to focus on. To show environmental responsibility, the airline presents several initiatives such as the campaign launched in 2022 called 'Fly the greenest': "Dear customers, When you don't need to fly, please, don't. But when you do, fly the greenest." (Wizz Air, 2023).
The Wizz Air campaign presents seven reasons why it is the greenest choice.

7 reasons	
1.	"A passenger travelling with us will have a CO_2 footprint of only 52.0 g/km on average, which is the lowest among our major competitors." (Based on the reporting for 2024 FY).
2.	"We don't fly half-empty planes to avoid unnecessary pollution."
3.	"We don't have business class seating, another example of needless emissions."
4.	"We only fly direct routes. One take-off, one landing, no connecting flights, no ectra fuel-burn."
5.	"We use the most modern and best-in-class engines and aircraft, crucial for low emissions."
6.	"We have one of the youngest fleets in the world among airlines with 200+ aircraft."
7.	"On top of all this, none of our routes have a direct train alternative under four hours."

Table 3-2: 7 reasons why it is the greenest choice.
Source: Wizz Air, FLY THE GREENEST

The seven reasons reported in the Table 3-2 are Wizz Air's presentation of why you should decide to fly with this airline, as it presents itself striving to be environmentally responsible. It is evident how the airline's core missions are to serve more passengers every day, offering the lowest fares in the most sustainable way.

Price Leader	Affordable Air Travel	New Travel Experiences
Latest Technology and Innovation	Best Service	Growing market share

Table 3-3: Main aims of Wizz Air.
Source: Own creation

Sustainable Strategy

In the Wizz Air's Annual Sustainability Report (FY24), they state: "Our Sustainability strategy is seamlessly integrated with Wizz Air's vision". By 2030, their aim is to achieve WIZZ500 fleet; in order to be able to realise this goal, they set 15 specific objectives aligned with their sustainability ambitions.

The table below called 'sustainable strategy tracker' shows the four pillars of sustainability and the key objectives and their current status; in both case when the target is achieved or in the case of long-term, the present trend is positive.

Sustainability pillar	Commitments	Current Status
Environment	"Qualify a sustainable aviation fuel (SAF) supply chain from 2025."	"On target. Two equity investments in sustainable aviation fuel research, partnerships with SAF suppliers and aspiration to fuel flights with 10 per cent SAF blend by 2030."
	"Drive noise reduction by ensuring all our fleet is complaint with the applicable noise emission standards by 2028."	"On target. 80 per cent of our aircraft are compliant as of F24."
People	"Continue to put safety first, in everything we do."	"On target. Cross-functional safety council meets four times a year. Dedicated Safety, Security and Operational Compliance Committee of the Board since F23 for additional oversight."
	"Further improve gender diversity in the Board, management, and flight deck to achieve: 1. 33 per cent female gender diversity in the Board of Directors; 2. 40 per cent female gender diversity in the management team by F26;"	"1. Board of Directors: 36 per cent – target reached. 2. Management team: 35 per cent. 3. Flight deck: 5 per cent."

Sustainability pillar	Commitments	Current Status
People	"3. 7 per cent female gender diversity in the flight deck by F30."	-
Governance	"Ensure effective Board oversight of all elements of the sustainability strategy."	"On target."
	"Continue to improve our climate-related disclosures, work on our decarbonisation roadmap, and report on all scopes of greenhouse gas (GHG) emissions."	"Continuous work on climate disclosures and alignment with reporting frameworks such as the Task Force on Climate-related Financial Disclosures; Global Reporting Initiative; Carbon Disclosure Project; and GHG inventory Scope 1, 2 and 3 reporting with a third-party assurance since F23."
	"Environmental target integrated into the incentive scheme for the CEO and the entire management team."	"Incentive scheme in place since 2021."
	"Gender diversity target for management integrated into the incentive scheme for the CEO and Officers."	"Incentive scheme in place since 2021."
Economy	"Grow our fleet to 500 aircraft by 2030."	"On target to achieve goal by F30. Current Fleet: 208 aircraft."
	"Increase the number of customers from 40 million in 2019 to 170 million by 2030."	"On target to achieve goal by F30. Passengers in F24: 62 million (compared to 51 million in F23)."
	"Employ over 20,000 people directly and 125,000 people indirectly across the network."	"On target to achieve goal by F30. New employees hired in F24: 2,357 (total employee number: 8,044)."

Table 3-4: Sustainable strategy tracker.
Source: WIZZ AIR'S ANNUAL SUSTAINABILITY REPORT, Strategic report – financial year 2024

3.5. SWOT analysis

In the formulation of a strategic plan, it's opportune to perform a SWOT analysis for given insights about the Strengths, Weaknesses, Opportunities, and Threats of the airline. The SWOT matrix is part of the Harvard model (Cepiku, 2018), although the first proposal can already be found in Selznick (1957), and it serves to determine the competitive strategy (Invernizzi, 2014). The four quadrants, which derive from the intersection between the four groups of variables, contain the strategic issues and strategies that the administration intends to adopt in the medium to long term. This matrix allows the strategists to evaluate a firm's current situation and future prospects by simultaneously considering insights obtained from analysis internal factors (strength and weaknesses) and external factors (opportunities and threats), positive and negative, to derive strategic implications. Managers use SWOT matrix to develop strategic alternatives for the firm.

Strengths	Weaknesses
• Strong financial perform • Wizz Discount Club • Have a low unit cost and offers low fares • All you can fly • High market share in Central & Eastern Europe • Youngest fleet (average age of less than 4.2 years) • Rapid growth in the revenue turnover • Robust investment in the staff learning and development • Recognise as the the Greenest airline • Ancillary revenue performance (in-flight food, luggage fees, seat selection, Wi-Fi)	• Low frequency of flights • Penalties on size baggage • Earnings rely on season
Opportunities	**Threats**
• Digitalization of customer journey to enhance experience • New emerging markets – possible network stretch	• Strong competitor – Ryanair, EasyJet • Potential disastrous due to natural cause • Exposed to fuel price changes • Substitutes (e.g., train, bus, etc.)

Figure 3-1: Wizz Air SWOT analysis.
Source: Own creation

3.6. Wizz Air's Approach to Sustainability

As mentioned previously, the aviation industry is committed to act and find solutions towards a sustainable transition as well as Wizz Air. In the sustainable report F24, Wizz Air stated their strategy in order to reduce climate change impact; includes renewing aircraft fleet, continuously enhancing operational efficiency and investing in sustainable aviation fuel (SAF). Wizz Air's efforts to mitigate the impact also go to the industry partners, ensuring emissions decrease during the supply chain and wider operations.

Wizz Air leads the airline industry as it can deliver the lowest levels of CO_2 per passenger kilometre at 52.0 grams in F24, instead in February 2025, 50.3 CO_2 grams per passenger/km. In the report Wizz Air unveiled to continue to be the most carbon efficient airline and remain committed to reducing emissions as well as driving the goal of the aviation industry in the decarbonisation pathway. What is more, in order to guide the decarbonisation, Wizz Air established their path towards decarbonisation, identifying the crucial elements to achieve this in the short, medium and long-term (see Figure 3-1).

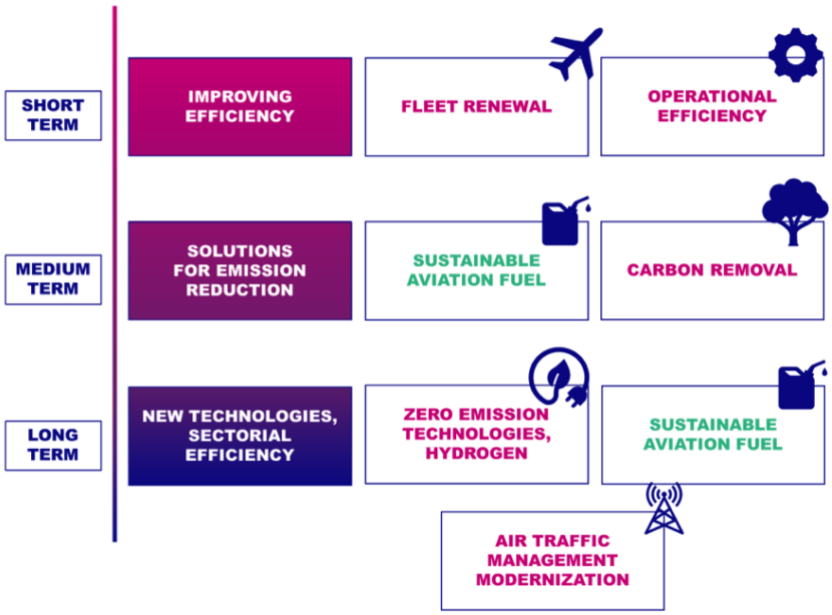


Figure 3-2: Wizz Air path to decarbonization.
Source: WIZZ AIR'S ANNUAL SUSTAINABILITY REPORT, Strategic report – FY24

As the graph shows in the medium term, the company in 2024 announced its aspiration to power 10% of its flights with SAF by 2030. The following goal will support the airline's commitment to reduce its carbon emissions per passenger/km up to 25% by 2030.

The airline made a significant step towards the adoption of SAF, as reported in the previous paragraphs, invested in SAF companies (e.g., Firefly, CleanJoule) and established partnerships with various suppliers. Nowadays, the use of SAF is considered to be a direct pathway to reducing emissions and achieve environmental goals. Firefly is a pioneering biofuel company from UK, this collaboration was born in 2023 and will be crucial to achieving Wizz Air's path to decarbonization. Firefly starting from 2028, can provide sustainable aviation fuel to Wizz Air's UK operations with up to 525,000 tonnes of SAF over the next 15 years.

Wizz Air has established four main environmental programmes with the intention to improve resource efficiency and decrease the impact of climate change. It aligns with the ESG goals.

1. *Focus on carbon intensity (CO_2/RPK) reduction and resource efficiency*

This is the first priority and the most important environmental commitment, which highlights the efforts that Wizz Air is putting in order to gradually reduce climate impacts during its flight operations through:

1. Fleet renewal; and
2. Fuel efficiency.

As discussed above, Wizz Air was awarded as Environmental Sustainability Airline of the year by CAPA which means that it is following the right path towards a sustainable flight. Hence, Wizz Air has established a target of 42.6 CO_2 grams per passenger/km by F30, compared to 57.2 of grams per passenger/km in F20 (see Figure 3-2).

	F20	F21	F22	F23	F24	F25	F26	F27	F28	F29	F30
CO_2 per RPK (in grammes) – planned	57.2	77.3	62.9	51.1	48.9	47	45.1	44.1	43.1	43	42.6

Figure 3-3: Wizz Air - CO_2 per RPK (in grammes) - planned.
Source: WIZZ AIR'S ANNUAL SUSTAINABILITY REPORT, Strategic report – FY24

2. *Sustainable Aviation Fuels*

The second priority of the Wizz Air environmental programme is sustainable aviation fuels with the goals and key levers:

- To qualify a SAF supply chain by 2025;
- Invest strategically in SAF Research & Development to secure their own sources of SAF; and
- Establish, increase partnerships and call to action.

The Figure 3-3 below shows Wizz Air's bases in Europe supplying SAF, airports regularly offering SAF are highlighted with pink. What is more, it illustrates that solely eleven airports where Wizz Air has a base offer sustainable aviation fuel, which means that sustainable aviation fuels still need to be supplied in many European's airports as well as it necessitates new technological advancements and suppliers in order to make the aviation industry more sustainable.

Figure 3-4: Airports supplying SAF for Wizz Air.
Source: WIZZ AIR'S ANNUAL SUSTAINABILITY REPORT, Strategic report – financial year 2024

3. *Noise emissions reduction*

The third priority, Wizz Air stated in its sustainability report F24, its commitment to noise reduction from its fleet. The airline recognises its impacts during the operations such as noise pollution and air quality on the locals living close to the airport. Wizz Air addressed those impacts through the fleet renewal programme which will continue to yield significant noise reduction benefits annually.

Doing so, for instance, the A321neo offers nearly a 50% reduction in noise compared to the A321ceo. This revealed a clear distinction in noise emissions between the present and old generation aircraft.

Nowadays, all Wizz Air's aircraft meet the ICAO Chapter 4 noise emission standard (require the aircraft to be at least ten effective perceived noise decibels quieter than Chapter 3), and 80% meet the Chapter 14 emissions standard (require the aircraft be at least seven effective perceived noise decibels quieter than Chapter 4). Apart from 41 A321ceo aircraft do not meet the Chapter 14 noise emissions standard. The airline projects that 100% of its fleet will meet this standard by 2029.

4. *Industry collaboration*

The ultimate priority highlights the importance of collaboration and active support of the aviation ecosystem towards green growth and decarbonisation. Wizz Air commitment goes

beyond fleet renewal, operational efficiencies; they collaborate with suppliers, partners, and other stakeholders on projects regarding efficiency and innovations.

One objective was achieved in 2023 was the electrification of ground handling process. Wizz Air had its first fully electric turnaround at Rome Fiumicino Airport. The turnaround process involved various steps employing electric equipment in order to prepare Wizz Air's aircraft for the next take-off once it landed. Consequently, electric turnaround allows Wizz Air to reduce carbon emissions from the ground handling process per aircraft by up to 85% in contrast to use diesel powered equipment. In the same year Wizz Air performed a fully electric turnarounds at Budapest Airport.

The low-cost airline underlines the importance of the industry collaboration in order to successfully address and mitigate the current climate change.

Other green initiatives promoted by Wizz Air

Airbus - ZEROe Hydrogen project. In January 2022, Wizz Air and Airbus signed a ZEROe Memorandum of Understanding, to analyse the potential of hydrogen-powered aircraft operations. The main topics of the partnership are the evolution of the ecosystem and sharing insights on operational opportunities and challenges in order to determine how a zero emissions aircraft can be implemented within Wizz Air's network. What is more, another green action is ELeather – aircraft seat covers made sustainably. As stated previously, Wizz Air commitment is not only active to deliver fuel efficiency and decarbonisation initiatives, but it goes beyond that, it supports resource efficient processes across the supply chain. Since 2012, the airline's aircraft have been outfitted with Gen Phoenix ELeather's seat covers. The ELeather manufacturing ecosystem is naturally sustainable. They are committed to recycling waste leather, into a resilient material with strong environmental benefits.

Wizz Airline acknowledges the value of biodiversity, as it is the lifeblood of our planet's ecosystems and human life itself. Therefore, it implanted in its supply chain the WWF's Biodiversity Risk Filter in order to mitigate potential impacts and to safeguard our planet. Furthermore, Wizz Air shared the value with its main stakeholder, customer, recognising the impact of its operations and its passenger' decisions can make on biodiversity. In 2024, the airline launched a biodiversity educational campaign, sharing beneficial information and recommendations with its passengers concerning the adoption of sustainable procedures when travelling and during their holidays. The following newsletter was a great success for the airline, it was sent out to up to 6 million subscribed customers.

4. Ryanair Business Case

This chapter analyses the two leading low-cost carriers in Europe, Wizz Air and Ryanair with a strong focus on their sustainability commitment. Indeed, it will be investigated in-depth the sustainability performance and indicators of both airlines to better understand how these airlines address sustainability through a comparative analysis of sustainability. Once highlighted the distinction, there will be a detailed analysis towards fly net-zero emissions.

As stated, in chapter 3 low-cost airlines are companies that do not offer many traditional passenger services as a part of the fare, instead they offer low price at the expensive of fewer comfort and service. In order to compare the key distinctions of the two airlines, it is necessary to provide an overview description of Ryanair, as for Wizz Air is presented in chapter 3.
Ryanair is a leading Irish low-cost airline and one of the world's largest airlines based by international passenger carried with headquarter in Dublin, Ireland. It was the first successful low-cost carrier to be established in Europe. Initially founded as "Ryanair DAC" in 1984, then the airline turned into Ryanair Holding Plc. as a parent company of Buzz, Lauda, Malta Air, Ryanair, and Ryanair UK. Today is operating with approximately 3,600 daily flights with more than 90+ routes, connecting more than 230+ airports in 37 countries, becoming one of the largest and most successful low-cost airlines worldwide.
Considering it is a low-cost airline, its business model is based on minimising its operational costs, which allow them to offer low fare, giving access to air travel to everyone. The airline adopts a point-to-point business model as well as Wizz Air, operating flights between secondary airports, most of the time outside major cities. Although, Ryanair has been criticised for its other strict policies such as its baggage policy and customer service, nevertheless they airline keeps growing and attracting millions of passengers annually, solely in the 2024/2025 year carried over 200 million passengers, marking an historic new record for Ryanair and for all the European airlines.

To further investigate how Ryanair addressed sustainability concerns regarding the environmental dimension, this paragraph will scrutinize the sustainability report for the fiscal year 2024, covering the period from 1 April 2023 to 31 March 2024.
As Ryanair is the leading low-cost airline in Europe in terms of passengers carried annually, it has a dominant position, therefore Ryanair's role in addressing the sustainable future of the airline industry is extremely relevant. In particular, the Irish low-cost airline declared its support

for the 2015 Paris Agreement, the United Nations Global Impact and the 17 UN Sustainable Goals, announcing in 2022, its ambition to reach the net-zero carbon emission long-term goal by 2050. The table below shows the Fiscal Year 2024 actions adopted by Ryanair in order to mitigate its operating emissions.

Pathway	% Commitment to 2050 Target	Field
Technological Improvements	32%	Fleet Renewal (210 Boeing 737 in the fleet by FY25) New technologies Load, Transport, and offload cycle efficiency
Sustainable Aviation Fuel	34%	Use of alternative fuels (Power 12.5% of flights using SAF by 2030)
Single European Sky Initiative	10%	In flights efficiency, a European commission initiative in order to improve efficiency and safety of air traffic management
Carbon Removals	24%	Removal project to achieve fly net zero emission by 2050
Energy Efficiency	100%	Renewable energy used in Dublin Buildings and in the hangars in Sevilla, Stansted, and Vienna
Supply Chain Engagement	100%	Vehicle electrification

Table 4-1: FY2024 Ryanair Actions.
Source: Ryanair Group 2024 Sustainability report

In addition of the actions that Ryanair Group embraced and is taking in the present year, the low-cost airline set environmental goals towards net-zero emission by 2050.

- 50 CO_2 grams per passenger/km by F31
- 12.5 % Sustainable Aviation Fuel by 2030
- 35% Scope 2 (indirect greenhouse gas emissions) absolute emission reduction by 2030
- 50% non-fuel scope 3 absolute emission reduction by 2030 (indirect greenhouse gas emissions from asset not owned by the airline but occur in its value chain)

With the aim to achieve the Paris Agreement targets and the ICAO's net-zero goal by 2050, Ryanair set up a plan called Climate Transition Plan ("The Plan") ensuring a path of decarbonisation.

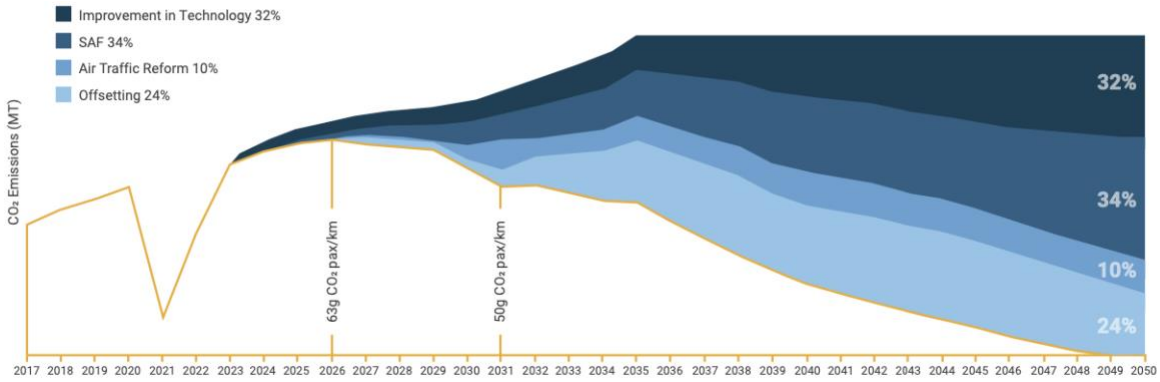


Figure 4-1: Ryanair Pathway to Net Zero.
Source: Ryanair Group 2024 Sustainability report

By noting Figure 4-1, we can observe that Ryanair claims that a significant part of CO_2 emissions could be reduced by implementing sustainable aviation fuel (34%) in its flights, secondly, on technological improvements (32%), which, according to ICAO, are essential drivers to achieve a successful decarbonisation path.
Ryanair disclosed a further reduction in its emission intensity regarding the FY2024, which decreased to 65 gCO_2 pax/km, compared to 66 gCO_2 pax/km in the FY2023.

4.1. Comparative Analysis of Sustainability

This paragraph intends to demonstrate the realisation of a comparative analysis of sustainability between two low-cost airlines, understanding their environmental emissions. The next paragraphs examine deeply the sustainability performance and indicators of two major low-cost airlines in Europe, Wizz Air, and its industry peer's leader Ryanair Group, by comparing and evaluating Wizz Air's reporting practices and performance against Ryanair Group. The comparison is extended to several key sustainability indicator, eight in total: Greenhouse Gas (GHG) Emissions, CO_2 per RPK, Average Fleet Age, Use of Sustainable Aviation Fuel (SAF), Net Zero Target Strategy, Carbon Disclosure Project, ESG Risk Ratings, S&P Global ESG Score. The rationale behind these indicators was based on a verification of amount of data that is accessible for the comparison.

What is a comparative analysis of sustainability?
Comparative analysis of sustainability involves comparing sustainability indicators used by companies to track their environmental commitment to one another, and contrasting similarities

and differences. In this case, airlines may conduct this analysis to examine the various strategies of direct and indirect competitors.

Greenhouse Gas (GHG) Emissions

The pillar that will be analysed is the environmental pillar of sustainability. Comparison between Wizz Air and Ryanair regarding greenhouse gas emissions takes as a reference the total of direct and indirect emissions produced by companies in thousands of tons of CO_2 equivalent (tCO_2e). The airline's operation generates different greenhouse gas emissions, distinguished by different emissions profile. The airline industry involves scope 1 emissions, which corresponds to the direct emissions generated by the airline during their operations mainly led by jet fuel consumptions and natural gas usage, but also scope 2 emissions from indirect emissions such as purchased electricity and heat, and scope 3 emissions from indirect operating emissions further up the supply chain such as fuel extraction, transportation and refining among others. The two pie charts below illustrate the total greenhouse gas emission breakdown (tCO_2e) of Wizz Air and Ryanair in the fiscal year 2024.

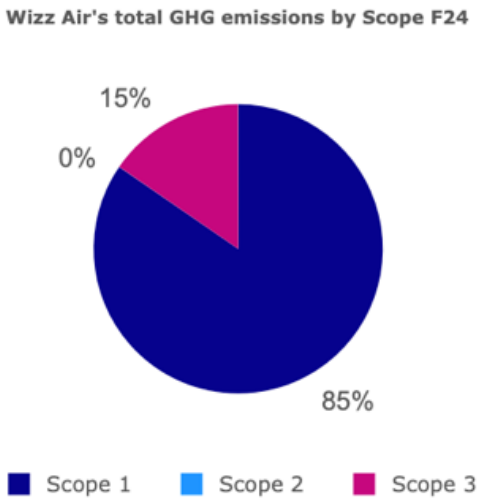


Figure 4-2: Total GHG emissions of Wizz Air.
Source: WIZZ AIR'S ANNUAL SUSTAINABILITY REPORT, FY2024

The pie chart illustrates the total GHG emission for both Wizz Air and Ryanair in the fiscal year 2024. Wizz Air's GHG emissions were approximately 7.5 million CO_2 equivalent. In contrast, the pie chart below represents Ryanair's GHG emissions were close to 18.6 million CO_2 equivalent. In this comparison, Wizz Air produce lower GHG emissions than Ryanair.

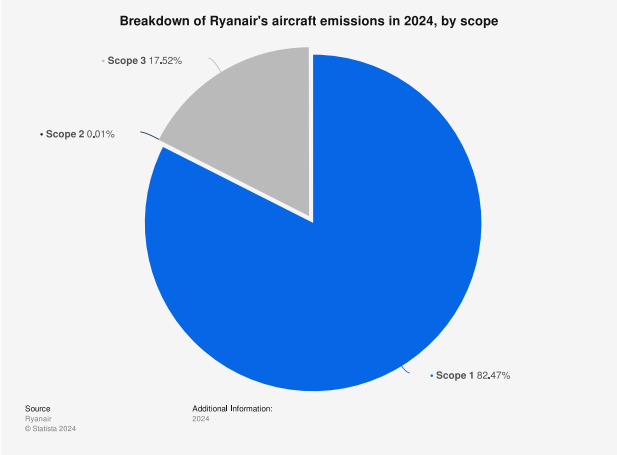


Figure 4-3: Total GHG emissions of Ryanair.
Source: Statista

CO_2 per RPK

As mentioned in chapter 2, the airline industry contributes to global carbon emissions for around 2.5% of global CO_2 emissions. Nevertheless, carbon dioxide CO_2 accounts for the majority of the total greenhouse gas emissions, therefore it considered one of the most relevant indicators in the aviation industry. The standard metric used by airlines to measure their environmental impacts is CO_2 per RPK, these terms indicate the quantity of carbon dioxide emitted by an aircraft for every revenue per passenger transported for a distance of one kilometer. The following chart below shows the grams of CO_2 per RPK of Wizz Air and Ryanair for the last 4 years.

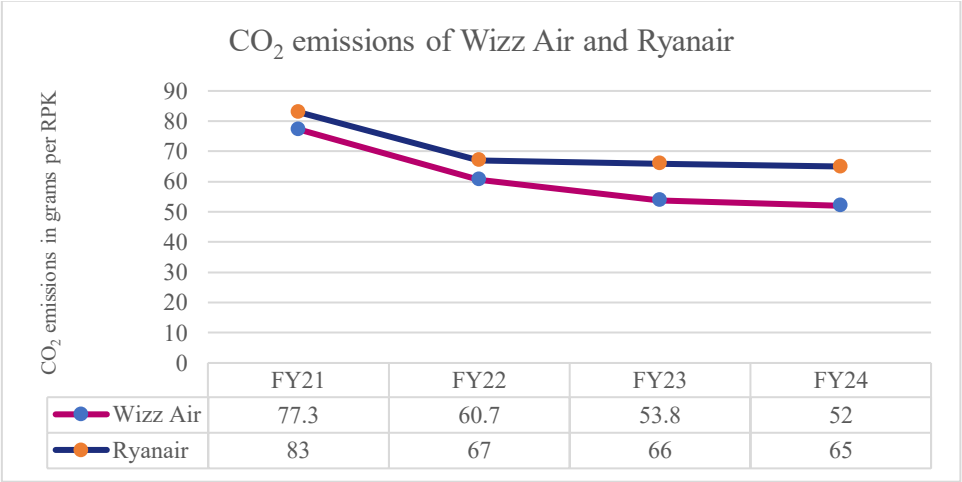


Figure 4-4: CO_2 per RPK (in grammes).
Source: WIZZ AIR'S ANNUAL SUSTAINABILITY REPORT, FY2024 and Our Emissions Ryanair

As can be seen from the comparison above, Wizz Air from the fiscal year 2021 emitted less CO_2 per RPK which is significantly lower every year compared to Ryanair. Therefore, Wizz Air is the low-cost among those two with lower emissions.

Average Fleet Age

The average age of an airline fleet is an important indicator of airline sustainability. Nevertheless, studies demonstrates that the low-cost carrier in average operates with the youngest fleet compared to legacy airlines. The aviation industry is working to mitigate carbon emissions and achieve fly net-zero targets by 2050, therefore newer aircraft are designed to embrace sustainability being fuel-efficient due to their lighter materials and emit lower CO_2 compared to old fleet, contributing positively to the environment. The Table 4-2 below represents the average fleet age for Wizz Air and Ryanair in the fiscal year 2024 and 2023.

Airline	FY23	FY24
Wizz Air	4.6	4.3
Ryanair	9	9

Table 4-2: Average Fleet Age per fiscal year.
Source: WIZZ AIR'S ANNUAL SUSTAINABILITY REPORT, FY2024 and Ryanair 2023 Annual Report

In comparison with Ryanair, Wizz Air ranks well below the average fleet age of the peer competitor. However, Wizz Air is also known for its young fleet age, becoming a leader in this area among various airlines, both in Europe and in the world.

Use of Sustainable Aviation Fuel (SAF)

As discussed in chapter 2, the use of sustainable aviation fuel (SAF) is one of the remedies to mitigate aircraft emissions, which is an alternative fuel made from biomass, algae, and household waste, able to provide significant reductions in overall CO_2 lifecycle emissions by up to 80% when compared to fossil jet fuel.

Both Wizz Air and Ryanair set actions to accelerate the adoption of sustainable aviation fuel. Wizz Air aims to power 10% of its flights with SAF by 2030, while Ryanair aims to operate 12.5% of its flights with SAF by 2030. It should be noted that, despite Wizz Air is the most

environmentally sustainable airline globally, in the following comparison, Ryanair ranked first for the power of sustainable aviation fuel by 2030.

Net Zero Target Strategy

Both airlines established a pathway towards net-zero emission by 2050. The table below illustrate the airline's actions that will bring the long-term goal set by ICAO, aspiring to achieve net-zero carbon emissions by 2050.

Airline	Wizz Air	Ryanair
ACTION	Wizz Air's plan is composed by five fundamental pillars:	Ryanair's Group plan is composed by four fundamental pillars:
Sustainable Aviation Fuel	"53% decarbonisation through the increased use of SAF."	"34% of carbon emission reduction targets delivered with increased use of SAF."
Technological advancements and operational efficiencies	"21% decarbonisation through technological advancements in aircraft and engine technology and 2% decarbonisation through operational efficiencies."	"32% of carbon emission reduction targets to come from technological and operational improvements."
Fleet Renewal	"7% decarbonisation through fleet renewal."	-
Air Traffic Reform	"4% decarbonisation through air traffic reform."	"10% reduction in emissions with the introduction of the Single European Sky initiative."
Other offsetting measure	-	"24% of emission reduction target to occur with offsetting and other economic measures."

Table 4-3: Pathway to Net-Zero.
Source: WIZZ AIR UNVEILS ITS ROADMAP TO NET ZERO BY 2050 – A MANIFESTO FOR URGENT ACTION IN AVIATION and Ryanair Our Pathway to Net Zero

It should be noted by this comparison that both airlines are committed to achieve a fly net-zero goal. Therefore, half of the Wizz Air's path towards the decarbonisation rely on the sustainable aviation fuel (SAF) adoption as well as for Ryanair Group, but it's not the only actions because it also relies on technological and operational improvements which will help the airline to reduce its operating emissions.

Carbon Disclosure Project

The Carbon Disclosure Project (CDP) is an international non-profit organisation that manages the global environmental impact system for public and private organisation, with over 23,000 companies disclosing in 2024. Its main objective is to promote sustainable economy, mitigating climate change and contributing to a net-zero future.
The CDP scores are established each year by a questionnaire. The following method is used to show organisations and stakeholders where they stand on three themes: climate, forest, and water through disclosure. Companies that respond are evaluated and graded from A to D, while companies that fail to do so are given an F by default. Brief explanation of the letter's grade:

- A grade, organisations must demonstrate leadership in the industry embracing good practices in terms of strategy and action in environmental concerns.
- B grade, organisations must demonstrate awareness of their environmental impact and act in managing this impact. They are not leaders in the sector.
- C grade, organisations must demonstrate a commitment to raising awareness of their environmental impact.
- D grade, organisations must demonstrate that they have begun their enviromental journey.

Once introduced, the Carbon Disclosure Project, it is important to compare the two airlines' companies. According to LARA a widely respected magazine for the aerospace community, Wizz Air in the fiscal year 2024 obtained a B grade in the CDP for the second consecutive year. While Ryanair received an A grade from the CDP in the fiscal year 2024, thanks to the broad Ryanair's plan towards the decarbonisation. The following comparison reveals Ryanair as one of the leaders among low-cost airlines in Europe, according to the Carbon Disclosure Project.

ESG Risk Ratings

Morningstar Sustainalytics 'ESG Risk Ratings' measure the degree to which a company's economic value (enterprise value, such as debt and equity) is exposed to risk driven by Environmental, Social and Governance (ESG) factors. In 2024, it covered over 16,500 companies. The ESG Risk Ratings assess and disclose how big an organisation's unmanaged ESG risks are. Unmanaged risk for every organisation is measured by assessing a set of material ESG concerns based on two dimensions: the organisation's exposure to material ESG risks and how well a company is managing those risks. The total unmanaged risk for each issue is summed up to create a final rating score that is the organisation's overall ESG risk. The ESG Risk Ratings measure a company's unmanaged ESG risks: 0-10 (Negligence Risk), 10-20 (Low Risk), 20-30 (Medium Risk), 30-40 (High Risk) and 40+ (Severe Risk). A good ESG Risk Rating score is between 0-20 where companies are considered to have good ESG risk management.

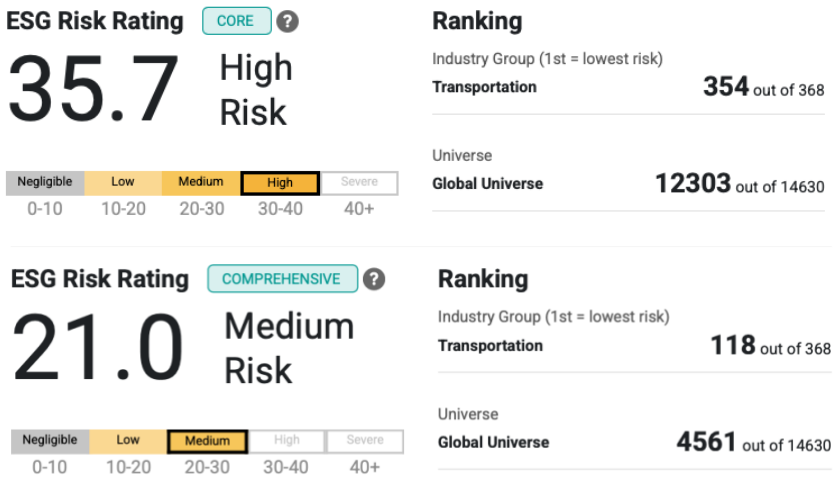


Figure 4-5: Wizz Air's (t) and Ryanair's (b) ESG Risk Rating. Source: sustainalytics.com

The Figures 4-4 and 4-5 above show the airlines ESG Risk Rating, on top Wizz Air and at the bottom Ryanair. As it can be seen from the comparison, Ryanair is significant below Wizz Air's ESG Risk Rating respectively 21.0 (Medium Risk) and 35.7 (High Risk), classifying in the industry group of transportation 118th out 368 instead Wizz Air is classified 354th out of 368. It should be noted that the huge difference is in the Global Universe rank where Ryanair stands out at 4561 places out of 14630 instead Wizz Air stand out at 12303 places of 14630.

S&P Global ESG Score

An additional ESG indicator is the S&P Global ESG Score, which measures a company's sustainability performance and how well the company manages ESG risks, opportunities and impacts compared to its industry peers within the same industry. In 2024 covered over 13,000 companies globally. ESG scores are calculated on a scale from 0 to 100, where 80-100 represents the highest score (excellent performance), 79-60 (good performance), 59-40 (average performance), 39-20 (below average performance), 19-0 (poor performance). A good S&P Global ESG score is above 60, which indicates a good to excellent performance.

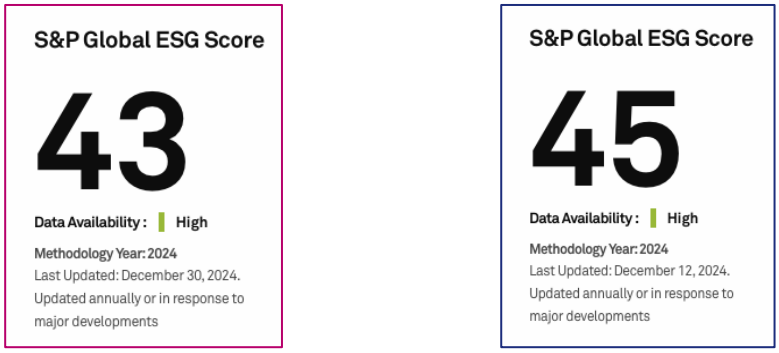


Figure 4-6: Wizz Air (L) and Ryanair's (R) S&P Global ESG Score. Source: spglobal.com

Figure 4-6 reports Wizz Air on the left side and Ryanair on the right side their respective S&P Global ESG Score indicators. It should be noted that both airlines stand out in the same score classified as an average performance in the industry. According to the scale, Ryanair is positioned 2 scores ahead Wizz Air, nevertheless it stands in the same score range.

4.2. Final remarks

The comparative analysis of sustainability conducted between Wizz Air and Ryanair, reveals that despite Wizz Air was awarded as the environmental sustainability airline group of the fiscal year 2024 by CAPA likewise Ryanair, is a leader for sustainability initiatives, they employ different approaches and path towards a common goal, fly net-zero.

What it should be noted is that Wizz Air leads the total greenhouse gas emissions by Scope F24 with less than half of the CO_2 equivalent emitted by Ryanair. Moreover, as can be seen from the Figure 4-3, from 2021, Wizz Air emissions in terms of CO_2 in grams per RPK are much

less when compared to Ryanair. A significant difference can be seen in the fiscal year 2024 with respectively 52g and 65g per RPK. Considering all the available indicators of greenhouse gas emissions, Wizz Air it can be considered greenest when compared to Ryanair in terms of emissions.

According to what was disclosed by both airlines, when taking into consideration the average fleet age that as stated above, is an important indicator when talking about airline sustainability, Wizz Air ranked first having younger fleet age in contrast to Ryanair in both fiscal years with an average fleet age of 4.6 and 9 years for the FY2023, similarly for the FY2024 respectively 4.3 and 9 years. As a result of this indicator, it can be seen that Wizz Air travels with the youngest fleet. However, when comparing the use of sustainable aviation fuel, it should be noted a slight difference where Wizz Air aims to power 10% of its flights using SAF by 2030. On the other hand, Ryanair aims to power 12.5% of its flights using SAF by 2030. The mentioned performance shows Ryanair having a higher commitment to power a higher percentage of its flights using SAF. On balance, it is their pathway to net-zero emission by 2050, both companies disclosed actions which will lead them to a decarbonisation pathway.

Lastly, multiple sustainability indicators have been compared. The first indicator analysed is the Carbon Disclosure Project, which ranked Ryanair as the leader in terms of strategy and action in environmental issues assigning an A grade, differently to Wizz Air, which obtained an B grade, classifying it as non-leader in the sector. The second indicator is ESG Risk Ratings by Morningstar Sustainalytics, Figures 4-4 and 4-5 illustrate the different ratings, Ryanair obtained a better rating classified among medium unmanaged ESG risk in contrast Wizz Air classified as high unmanaged ESG risk, the mentioned indicator reveals a huge gap between these two airlines. The ultimate indicator is the S&P Global ESG Score, which reported both low-cost carriers in the same group of performance that is classified as average performance in the industry, with respectively 43 for Wizz Air and 45 for Ryanair.

Overall, both companies are committed to embrace sustainability, it is evident that Wizz Air produces fewer greenhouse emissions when compared to Ryanair, thanks also to its young fleet. Nevertheless, it should be noted that Ryanair has a bigger fleet and continues to be the leading low-cost in terms of passengers carried each year compared with Wizz Air. In contrast, Ryanair is ahead of Wizz Air, in its commitment to powering SAF for its flights by 2030, as well as for its placement in CDP, ESG Risk Rating and S&P Global ESG Score.

5. Future of the Aviation: Pathway to Net-Zero Emissions

This chapter examines the objective of this thesis, which is an outlook on current future expectations of the aviation industry, in particular its commitment to achieving fly net-zero emissions by 2050. Air travel is an essential part of our society, enabling people to connect across the world, drive economic growth, among many other benefits. According to reliable forecasts, there will be an increase in the number of flights across Europe annually, roughly between 1% to 2.4% per year. However, the European aviation industry recognised the urgent need to address climate change. Hence, civil aviation has committed itself to achieve an ambitious goal based on science and aligned with the Paris Agreement aim to maintain the warming effect of climate change below 1.5ºC, aiming to achieve net-zero carbon emissions by 2050. The following transition to net-zero carbon industry is an ambitious goal, but it is doable; it requires cooperative action from all stakeholders, such as policy support from government and most importantly the energy industry which play a key role. According to Air Transport Action Group (ATAG) and International Air Transport Association (IATA), there are four main key strategies also known as 'Waypoint 2050' in order to achieve a decarbonisation of air transportation, as already reported in Figure 2-7:

- Increase use of sustainable aviation fuel (SAF) in the aviation industry, which contributes to 65% of emission reductions (see Figure 5-1);
- Investment in carbon offsets and carbon removal strategies, accounting for 19% of the reduction to achieve net-zero emissions;
- New technological advancements, including the introduction of electric/hydrogen powered aircraft, accounting 13% of reducing carbon emissions and
- Continued improvements in infrastructure and operations across the industry contribute to reducing carbon emissions up to 3%.

Sustainable Aviation Fuels

As already mentioned in chapter 2, the remedy to mitigate aircraft emissions is to deploy sustainable aviation fuel (SAF). In order to make SAF cut the emissions by up to 65% needed to achieve net-zero emissions by 2050, aviation requires a substantial increase and investment in the production of the mentioned fuel, with the aim of supplying almost 450 billion litres (Figure 5-1).

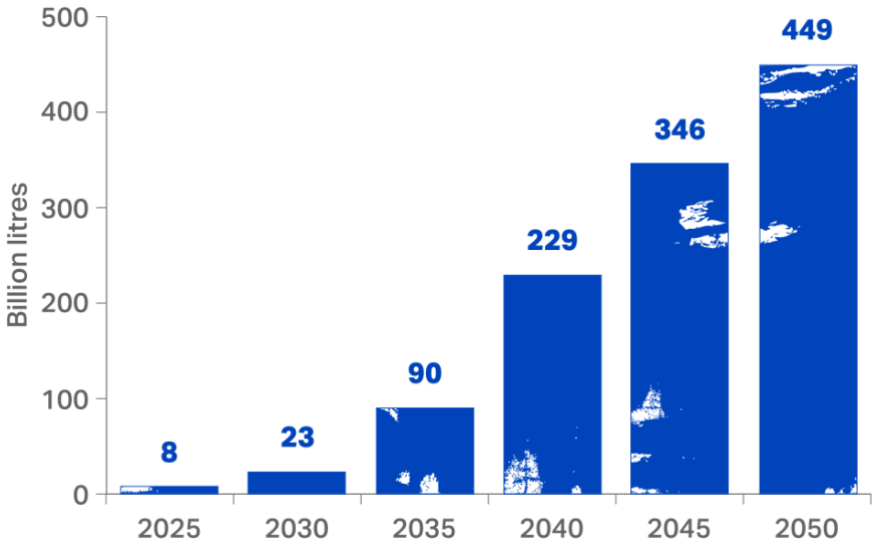


Figure 5-1: Expected SAF required for Net-Zero 2050.
Source: IATA.org

In the next section are listed the most important programs established to support and achieve net-zero carbon emissions by 2050.

Destination 2050

At the core of this commitment stands an industry alliance called 'Destination 2050' founded in 2021 by ACI Europe, Airlines for Europe (A4E), ASD Europe, European Regions Airline Association (ERA), CANSO Europe, devoted to making net-zero carbon emissions become reality. The alliance launched its first pathway report to decarbonising European aviation, in collaboration with Royal Netherlands Aerospace Centre (NLR) and SEO Amsterdam Economics.

They stated that a collaboration with policymakers and the industry can contribute to achieving net-zero CO_2 emissions by 2050. European aviation, including European airlines, airports, aerospace manufacturers, are determined to play its part in order to contribute to a sustainable growth for all flights departing from the EU, UK and the European Free Trade Association (EFTA).

Destination 2050 disclosed the actions and measures required to achieve a great reduction in CO_2 emissions by 2050, in national, European, and global contexts (see Figure 5-2).

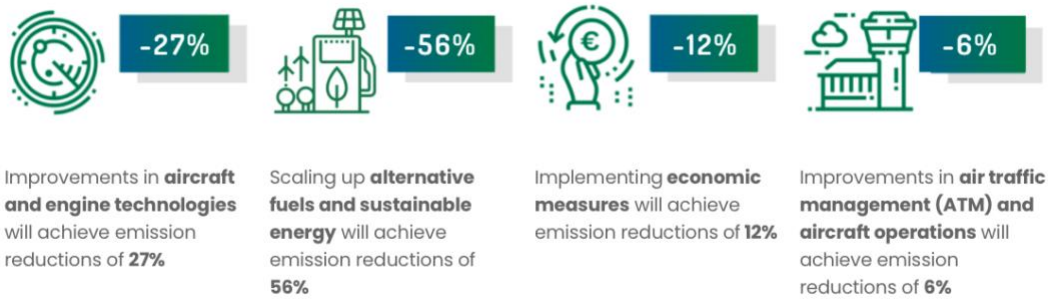


Figure 5-2: Key measures to achieve CO_2 emissions by 2050.
Source: Destination 2050

Additionally, according to Destination 2050, European flights are expected to growth by approximately 1.4% per year between 2024 and 2050. The following outlook will not impact the possibility to achieve the net-zero goal by 2050.

Alliance for Zero-Emission Aviation

The European Commission launched a voluntary initiative named the 'Alliance for Zero-Emission Aviation (AZEA)' leading the way for the adoption of hydrogen and electric powered aircraft. Nowadays, many airlines such as Air France-KLM, EasyJet, Wizz Air., airports such as Areoporto Guglielmo Marconi di Bologna, Aeroport de Bordeaux, universities such as Tu Delft, Norwegian University of Science and Technology are members of the alliance. The purpose is to offer another solution to overcome the challenge of zero emissions by 2050. In Figure 5-3 below, the European alliance discloses the potential benefits that could be brought in the adoption of next-generation aircraft.

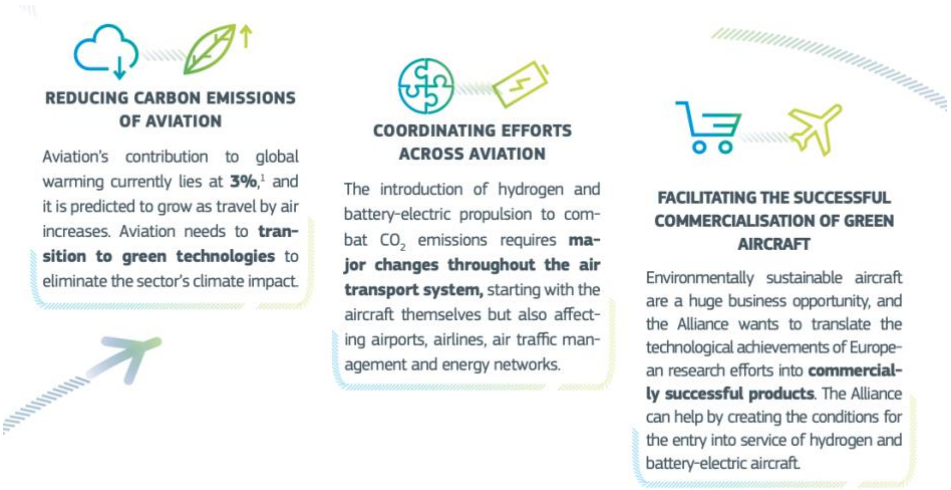


Figure 5-3: Why creates the alliance?.
Source: European Commission, 2022

The way it works, is simple:

- Connecting partners: the alliance is open to a wide range of stakeholders belonging to the industry.
- Establish recommendations: the working group established focus on concerns regarding infrastructure requirements, the development of new energy sources among others.
- Encourage investments: The alliance tracks every single step that goes through, towards hydrogen and electric aircraft. Doing so, attracts public and private investors.

The fundamental aspects are the benefits that the alliance can generate. For the environment, the use of hydrogen either in combustion turbines or fuel cells and battery electric propulsion will eliminate CO_2 emissions and reduce the other emissions. Figure 5-4 illustrates (in metric tons) the decarbonisation pathway for flights to the Intra-EU+ region. As it can be noted, the pathway is in continuous decline and the major contribution to achieving net-zero emissions is the adoption of sustainable aviation fuel, which have a similar performance to hydrogen.

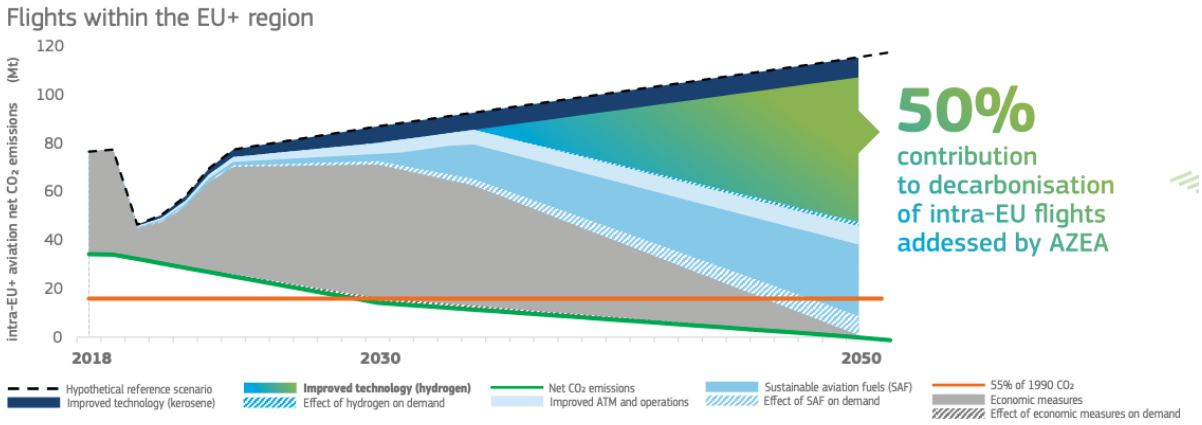


Figure 5-4: Environmental benefits of AZEA.
Source: European Commission, 2022

For the economy, the industry outlooks revealed that in the next 20 years more than 40,000 passenger aircraft will be sold, with a practiced market value of approximately of 2,500 billion. For the passengers, the introduction of zero emission aircraft will propose a new way of air travel. Besides what is mentioned, it will be safe, fast, and climate-friendly, connecting both major airports and minor airports which are not served yet by aircraft.

ReFuelEU Aviation

An additional program established in 2023 by the European Commission is the ReFuelEU Aviation, which incentives the use of sustainable aviation fuel as one of the strongest tools which allows decreasing CO_2 emissions. It establishes guidelines for aviation fuel suppliers to progressively increase the share of SAF blended into the regular jet fuel delivered at European airports. The notable facts shaped by the following program are reaching 2% of SAF share in European airports from 2025, reaching 70% of SAF share in European airports from 2050, reaching 2% of synthetic aviation fuels, which is a type of SAF produced from renewable resources in all European airports from 2030 and 35% of synthetic aviation fuels in all European airports from 2050. In order to be successful, the following initiatives, require the collaboration of three sectors: aviation fuel suppliers, aircraft operators and European airports.

Figure 5-5: Benefits from ReFuelEU Aviation.
Source: European Commission, 2023

Figure 5-5 above shows the benefits of ReFuelEU Aviation which will help the implementation and transition to the sustainable aviation fuel in the industry faster.

In conclusion, the future of the aviation industry is on the right path, implementing multiple initiatives and strategies to reduce its emissions. Despite, the European's future prediction of the increase of annual flights, the industry stands out its ambition, aligning itself with the Paris Agreement aim and ICAO's long-term goals. Thanks to the various initiatives such as 'Waypoint 2050', 'Destination 2050', as well as the 'Alliance for Zero-Emission Aviation (AZEA)' and 'ReFuelEU Aviation and strategies implemented involving the adoption of sustainable aviation fuel, technological advancements, and carbon offsetting by the main key players of the industry, it is evident, that all the aviation stakeholders are committed with a

strong effort to achieve net-zero emissions by 2050. Among the required measures to achieve net-zero emissions, as already mentioned multiple times, sustainable aviation fuel is seen as the main key driver to exponentially reducing emissions (see Figure 5-4).

However, what will make the difference in overcoming technological and infrastructure barriers required to reach the goal, is the collaboration between industry players (such as aircraft manufacturers, airlines, fuel providers, airports among other), policymakers and investors which will contribute to the development of sustainable air travel. As the data shows, the initiatives for sustainable aviation are various. Nonetheless, it is evident that the industry still requires developments and improvements to meet the net-zero transition.

6. Conclusions

This thesis aimed to stress the importance of the main concern of the current era, climate change. Looking for a brighter future, towards fly net-zero emissions by 2050. Companies recognise their substantial emissions; therefore, they are seeking to address this issue through corporate sustainability initiatives. Air transport, which constitutes one of the main means of transport, facilitating the connection from one point to another, is projected to increase in the upcoming years, leading to an increment of emissions associated to its operations. Considering the urgent climate issue and the forecasted growth in air travel, airlines must enhance their collaboration with the main industry players, policymakers, and governments to strongly address environmental issues. In particular, this work explores the environmental emissions produced by air travel, providing a broad overview of the main environmental impacts caused by air traffic, and finally reporting initiatives and cooperation between the major industry player to effectively mitigate climate change by implementing a decarbonisation's pathway permitting the industry to reach the ambitious goal of net-zero emissions by 2050.

In order to present real data regarding environmental emissions, this research exploit a comparative analysis of sustainability between two major European low-cost; Wizz Air, as a sustainability pioneer in civil aviation and Ryanair as the largest low-cost airline in Europe, revealing their contribution through sustainable strategies and actions towards fly net-zero emissions by 2050. The matter has been approached both from a quantitative point of view and stressing the importance of the airline's sustainability plan to achieve and pursue the target goal.

This work begins by providing a theoretical introduction of the foundation of sustainability, through historical development and first sign of degradation during the 20th century and describing the main elements that contributed to the introduction of the concept of "Sustainable Development". However, the evolution of the concept of sustainability has shaped the three pillars of sustainability. Following the introduction of the concept of sustainability, this research analysed the concept of climate change, mentioning the different changes that can be caused to the atmosphere and environment. In particular, sustainability over the years gained importance among corporations. Therefore, it is revealed the concept of corporate sustainability, explaining through examples and benefits the potential of sustainability when embraced in business.

After introduced the concept of sustainability, climate change and corporate sustainability, this research proceeds by presenting the aviation industry and its related sustainability impacts and initiatives. From the analysis on the impact of climate change, it should be noted that air travel has significant impact on it and on the air quality due to the emissions of toxis gases, both CO_2

and non-CO_2 emitted by aircraft engines. Besides, air quality also the aviation industry has a huge impact on noise pollution but nevertheless, thanks to various European initiatives and technological progression, the industry is mitigating its impact. Then, sustainability in aviation was introduced by explaining the pressure and the challenges that it is facing in order to reduce its environmental impact. It emerged that the short-term solution, able to reduce exponentially the emissions is the adoption of sustainable aviation fuel, the following fuel can blend and integrated with current aircraft, without any changes in aircraft's engines. Nevertheless, the long-term goal of the industry is to fly with 100% of SAF. Then, other's alternative green fuels emerged to replace SAF are Bio-jet fuel, Electro-jet fuels, Hydrogen, Liquefied methane, and Ammonia.

By closely analysing, Wizz Air on one hand, it can be noted that throughout the years the airline has been awarded by different entities, such as CAPA and World Finance for its sustainability commitment, being recognised as the greenest low-cost airline in Europe. In particular, the airline disclosed a manifesto reporting seven reasons why it's the greenest choice. Furthermore, it designed a decarbonisations path shaped by three different terms: short-term aims are improving efficiency (i.e., fleet renewal), medium-term aims are solutions for emission reduction (i.e., SAF) and long-term aims are new technological, sectorial efficiency (i.e., zero emissions technology, hydrogen). Moreover, it should be noted that Wizz Air is leading the transition to reducing emission in the industry, investing and established partnerships with SAF suppliers and manufacturing companies and promoting different green initiatives. By analysing, Ryanair on the other hand, has the same business model as a low-cost airline, it should be noted that Ryanair is also implementing various actions to mitigate the environmental impacts. It designed a pathway to net-zero emissions involving four objectives able to mitigate its emissions, primarily rely on the implementation of sustainable aviation fuel and technological improvements.

Based on the quantitative analysis between these two airlines, it can be concluded that concerning emissions, Wizz Air performs better than Ryanair. Nevertheless, it should take in consideration that Ryanair is classified as a larger airline than Wizz Air. Indeed, the results clearly illustrate Ryanair outperforming in the implementation of sustainable aviation fuel and excelling in all the sustainability indicators.

With the aim of pursuing net-zero emissions by 2050, as mentioned above, three main elements are required: improve aircraft efficiency, increase the adoption of sustainable aviation fuel, and optimase aircraft operations both in the air and on the ground. Therefore, implementing these solutions together with the adoption of hydrogen and electric aircraft can cut the emissions by

up to 70%. The solutions illustrated are going to be feasible if there is a contribution from various stakeholders, but in particular by the government's support in the development of SAF and by the producers.

According to Bain & Company study on net-zero emissions for aviation, the transition to the decarbonisations is likely to increase flight tickets by 2026. Their research revealed a real solution for airlines which consists of exploiting more efficient engines and aircraft. Doing so allows an optimal adoption of sustainable aviation fuel leading to in-flight optimisation. Following the mentioned approach, even though the growth of air traffic grows at 3% annually, the industry can reduce up to 70% of CO_2 emissions by 2050.

Another solution proposed, in which the airline can reduce their CO_2 emissions by up to 43% through fuel efficiency, given by the adoption of new engines and aircraft frames designed to cut emissions. For continuous improvement airlines should operate with a young fleet.

Nevertheless, the following initiatives are going to be at the expense of the industry. Indeed, without a change in government policy, the required SAF to reach the net-zero emissions which is roughly 390 million metric tons (449 billion litres), it will be limited to 135 million metric tons in 2050, representing only 35% of the forecast global demand. However, governments can contribute to the increments of available SAF in the global market by more than 110 million metric tons by 2050, delivering total SAF production to roughly 60% of the predicted global demand. The actions that the government should take include providing incentives to biofuel refineries with the aim of increasing SAF production, giving precedence to the aviation industry to access biofuel feedstocks, and leading green hydrogen produced by wind and solar power to SAF refineries. Doing so, it is possible to enhance the Fischer-Tropsch process.

The study disclosed that even with strong government support, it is unlikely that by 2050, SAF supply will be enough to meet the established goal by ReFuelEU Aviation and ICAO. In the absence of import, the EU will be able to supply roughly 85% of its target. It should be noted that the different types of SAF aren't equally effective at reducing emissions, deepening the pathway SAF may reduce between 65% and 90% of the emissions. Having mentioned the limitations and challenges that the industry will face in the upcoming year, the aviation industry is unlikely to reach its target goal, according to the consulting firm.

As stated, multiple times, the main driver of this ambitious goal is the adoption of sustainable aviation. Therefore, as noted by Bain & Company study the SAF price in 2050 will be two or three times higher compared to jet fuel due to unstable supply and demand, which will push up SAF prices. In order to achieve the required SAF supply aiming to the target, the aviation

industry will have to invest roughly between $1.6 trillion and $2.1 trillion. The adoption of new aircraft and increase price of SAF, will increase the overall cost by up to 18% by 2050.

This mentioned forecast will lead to an increment in the overall operations cost for the airlines. The transition will be at the expense of the airlines, it will require readapting the business model in order to survive and implement new strategies, such as investing in fuel production as Wizz Air and Ryanair are doing to reduce the SAF cost, find a solution to share the increment of the cost with customers, especially for low-cost carriers and decrease the operations costs among others. Even with a strong commitment by all the industry stakeholders, the transition to net-zero emissions for commercial flights is going to be drawn out and complex. Different predictions could change along with technological advancements and the path to completing decarbonisations is probably going to be longer than the target in 2050. It will probably cause tough challenges for airlines to survive in the upcoming new era, solely those who are ready for the transition will be able to stand out among the best positioned.

In conclusion, as mentioned before, despite Wizz Air being awarded as the greenest airline in Europe, Ryanair is deeply committed to reducing its emissions showing off by various sustainable indicators analysed in the qualitative analysis. Indeed, both airlines send a strong message to other airlines concerning their sustainability commitment. Instead, regarding the transition to net-zero emissions in the aviation industry, it should be noted that many initiatives and programs have been established by different stakeholders; nevertheless, the industry demands huge support from governments and policymakers in order to make relevant progress. Given these facts, the hope is that climate change will be constantly placed as a priority by governments and policymakers, enabling the transition to fly net-zero emissions by 2050, ensuring a prosperous future for society.

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