



## STRUCTURING A GREEN AIRPORT: EVIDENCE FROM PRACTICE

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**Abstract:** The growing environmental issues, the climate crisis, and new policy practices aimed at addressing these problems have led industries to explore solutions and prepare for change. This has been particularly significant for the air transport industry, which is considered a major contributor to environmental impacts through aviation emissions. Airports, as key components of transportation and economic systems, are increasingly developing green business strategies to address ecological concerns associated with their operations. The purpose of this study is to evaluate the design of green business practices at airports by examining current approaches. Accordingly, this study explored existing airport practices based on sustainability reports of nine European airports, three successful ACA cases and two airport groups using thematic document analysis. After the assessment, fourteen main themes and eighteen sub-themes were identified. According to the assessment, energy optimisation and green energy emerged as the most prevalent themes. The findings indicate that the airports included in this study are actively pursuing sustainability targets and advancing the green airport concept. However, the steps for transformation, progress levels, and key actions may vary depending on multiple factors. Hub airports demonstrated higher levels of investment in innovation than regional airports. The results further show that each airport is at a different stage of sustainable transformation. Therefore, it is important to recognise that sustainable transformation is not a linear process and requires continual adaptation. While essential regulatory frameworks, funding mechanisms, and support networks are being developed, there remains a constant need for external support to foster the green market. Key requirements include regulatory assistance, collaborative networks, financial structures, and comprehensive institutional restructuring. Finally, the study proposes an integrated transformation framework for a green airport, emphasising external drivers, internal assessment, a multi-factor system, and a dynamic design concept. Overall, the study provides an overview and assistance for future Green Airport implementations and design through an examination of ongoing practices.

**Keywords:** Aviation, Airport management, Air transport industry, Green airport, Green business design

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### 1. Introduction

Sustainability has become a significant driver of world economies and business operations. The deterioration of ecological health has substantial negative impacts and global issues. These problems could be due to increasing factors such as air pollution, emissions, ozone issues, the warming effect, or climate change (Dameris et al., 1998; Jarošová and Pajdlhauser, 2022; Nusa and Kodak, 2023). Currently, studies continue to explore the impact of transport on negative environmental results and generally accept air transport's significant contribution to CO<sub>2</sub> emissions (Lee et al., 2010; Ansell and Haran, 2020). Therefore, industries and businesses worldwide, including the air transport industry, have been exploring sustainable solutions.

The business-level implications of future climate change could include operational issues, demand imbalances, financial issues, impacts on the external environment, human well-being, and legal problems (Eurocontrol, 2021; Schipper, 2004). In terms of the air transport industry, these factors could also be listed similarly. However, the downside is that the air transport industry

is seen as a negative ecological actor due to the high level of carbon and other gas emissions, energy consumption, and noise pollution (Lee et al., 2010; Ansell and Haran, 2020). Additionally, air transport is competing with other green transport modes, and governments are increasingly encouraging people to choose green transport modes (European Environment Agency, 2021). ICAO forecasted a threefold emissions increase by 2050 compared to 2015 numbers (ICAO, 2025). Additionally, while aviation activities have a direct impact on global carbon dioxide emissions, airlines and airports have to consider GHG (greenhouse gas) emissions, NO<sub>x</sub>, nvPM emissions, air pollution, and energy (European Commission, 2025b; ICAO, 2019), as well as recreating systems for waste management (Sebastian and Louis, 2021), due to factors such as ground handling, fuel dependency, and high energy consumption. According to the 2022 numbers, the air transport industry has the largest GHG emissions after road transport, with 13.9% in all transport modes (European Commission, 2025b). Therefore, it is possible to suggest that the rapidly growing demand and aviation-related operations



increase the emissions from air transport-related activities. Additionally, due to the increasing external pressure, the industry needs to design sustainable business operations and implement green strategies to adapt to growing regulatory expectations, such as CORSIA (ICAO, 2019). Consequently, policies, public views, and sustainability regulations led airlines and airports to redesign business strategies and operations.

Historically, the air transport industry has been analysing environmental issues and the impact of air transport on climate change (Janić, 1999; Morrissette, 1996), assessing solutions, passenger behaviour or regulations (Goetz and Graham, 2004; Gössling, Humpe and Bausch, 2020). The air transport industry also experienced a substantial rise in passenger numbers, even after the COVID-19 pandemic, which halted this growth for three years (2019-2022). The global air transport market recovery started after 2022, and the increase is expected to continue (European Commission, 2025b), while rapidly increased traffic is seen as a threat to the industry's sustainability targets (Keskin and Erçoşkun, 2021). The International Energy Agency (IEA) mentioned that carbon dioxide levels have nearly reached the pre-pandemic levels in aviation due to the rapid traffic recovery in 2023 (International Energy Agency, 2025). Thus, the pressure on the transport industries and aviation to meet carbon-neutral goals and provide environmentally safe services has been increasing (European Environment Agency, 2021). Furthermore, it is possible to say that the air transport industry has significant pressure to transform into a green industry and requires fundamental changes.

The concept of sustainability and sustainable change is complex. For instance, sustainability has 3 key pillars that support the change: environment, society, and economy. The successful integration of these 3 factors could guide the change and support the organisation's sustainability goals (Maleviti, 2024). The United Nations (UN) also suggested that sustainability requires a holistic approach, which led to the establishment of the United Nations Development Programme (UNDP) to guide and design a system (UNDP, 2025). Thus, a sustainable system requires multiple layers of change, actions, and factors.

Previous research has assessed the impact of climate change and examined the implementation of organisational change to design sustainable business operations, such as shaping the regulatory environment (McManners, 2016), establishing a sustainable business model framework (Laasch, 2018), or developing sustainable business strategies (Dissanayaka et al., 2025). There are also studies on sustainable aviation and airport concepts, which provide an outlook on the green business development in various markets (Karadağ & Vural, 2025; Vural & Vural, 2024). Therefore, the design of Green Airport components has been highlighted in both the industry and academia. This business model supports the implementation of green practices at

individual parts of an airport's business operations and reshapes the systems (Ramakrishnan et al., 2023; Sreenath, Sudhakar and Yusop, 2024). Researchers also mentioned that developing and implementing this concept requires consideration of multiple operational and financial factors (Nair and Paulose, 2014; Mańkowska et al., 2023; Parhamfar, 2024). For instance, airport infrastructure and systems need to be redesigned or rebuilt to use hydrogen for green energy generation and fuel (Khalil and Dincer, 2024). Overall, the green business design and analysis include an internal business assessment in areas such as financial functioning, value creation, inner feasibility, social impact, or human factor (Boons and Lüdeke-Freund, 2013; Pfeffer, 2017). Most importantly, in each transformation step, available financial support for investments, cost, and risk analysis has to be included (Nakao *et al.*, 2007; Molina-Azorín *et al.*, 2009).

First of all, airports and airlines are two fundamental actors that lead and implement this transformation in the air transport industry. Second, the regulative environment is still developing, and rules are constantly changing. Some of these rules are local, country- or economic area-specific (i.e., European Union) (European Commission, 2025b), international (i.e., UN), or industrywide (i.e., Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA) (ICAO, 2019). Therefore, the implementations could present diverse practices and challenges. Third, this area requires ongoing development due to uncertainty in the air transport industry, evolving sustainability concepts, and the climate crisis. Lastly, there is still a need for guidance and a conceptual framework, as the green business concept is also an evolving area (Parhamfar, 2024; Sreenath, Sudhakar and Yusop, 2024). Consequently, this research narrates these gaps by analysing the current practices of selected European airports. At the same time, findings aim to develop an implementation framework for future studies and the industry that could add value. This conceptual framework and green transformation steps contribute to both theory and practice by synthesising and incorporating key themes from the literature and findings. In this context, the following questions have been explored:

RQ1: What are the main sustainability themes and ongoing actions at the selected European airport sample?

RQ2: How could these actions differ between airport types?

RQ3: How can airports integrate green business practices into existing operations?

## 2. Materials and Methods

This study employed an exploratory approach to evaluate ongoing green initiatives at selected European airports. Thus, airport actions, industry initiatives, and successful cases were examined to evaluate the airports' sustainability approach. This heading explains the

methodological foundation, including market and airport decisions, reports used, and the thematic review process. First, the European airport market has been selected for assessment. Due to privatisation, European airports' reports are open to the public and practice high transparency in terms of sustainability projects. Therefore, the accessibility of open reporting systems in the European airport market provided an opportunity. Additionally, private airports have diverse ownership and business strategies, which could also lead to an

opportunity to assess diverse sustainability approaches. Second, this study employed a combination of document review and content analysis to explore the chosen topic. Document review provides a systematic review option while researchers assess and categorise the vast amount of data through report-based information (Corbin and Strauss, 2008; Bowen, 2009). Table 1 lists the airports included in this study, along with the specific sustainability-related company reports and documents.

**Table 1.** Selected airports and reports

Category	Airport	Country	Report/Content
ACA Case Studies Airport Sources	NAP	Italy	Airport Carbon Accreditation (2024)
	STR	Germany	Airport Carbon Accreditation (2025b)
	FAB	UK	Airport Carbon Accreditation (2025c)
	AMS	Netherlands	Schiphol Group (2020)
	TLS	France	Aéroport Toulouse-Blagnac (2020)
	MUC	Germany	Pehr et al. (2001); Munich Airport (2024)
	LHR	UK	Heathrow Media Centre (2019); Heathrow (2025)
	LGW	UK	London Gatwick (2023, 2024, 2025)
	ZRH	Switzerland	Flughafen Zürich AG (2024); Zurich Airport Ltd. (2024)
	EMA	UK	East Midlands Airport (2024)
	BRU	Belgium	Brussels Airport Company (2025a); Brussels Airport Company (2025b)
	IST	Turkey	IGA (2024)
Airport Group Reports	AENA Group	Spain	AENA (2021, 2024)
	MAG Group	UK	Manchester Airports Group (2025)

Next, this study adopts a purposive selection of airport documents. The majority of airports selected had a dedicated website information page on 'sustainability' and provided special annual reports on the topic. Due to the open access and convenience of European airport reports, it was possible to include 15 airport reports in the assessment. During the data collection step, the airport sustainability reports, regulatory organisations, airport public statements, and ACI's Airport Carbon Accreditation (ACA) case examples from Europe have been combined. ACI's ACA program reported 10 successful case examples, 3 of which were European airports. These cases were included under the ACI case studies. The other chosen airports for the study offered public access and included multiple ongoing sustainability-related processes. Overall, the review sample comprises 9 airports, 2 airport groups, and 3 ACA airport cases. And 5 airports chosen for the sample are the top 10 busiest airports in Europe, with LHR and IST having the highest traffic numbers (OAG, 2025). Further, the airport sample has diverse business models (hub and regional), traffic types, and is geographically located in different parts of Europe. Additionally, key industry actors, such as ICAO, IATA, and ACI, have been explored. These include public statements, projects, and reports, to

observe regulatory compliance related to green transformation practices. Although the sample's limitations stem from its non-statistical nature, it offers a diverse perspective by including airports with different business models, countries, and networks across the European market.



**Figure 1.** Thematic analysis.

The specific method utilised for this study was a document review approach with an inductive content analysis. The recurring themes were identified through the document review and inductive process. These were conducted iteratively with comparative assessments and interpretation of multiple document contents and codes. The thematic grouping and coding have been done to categorise the information collected. Thus, the frequently highlighted areas of airport actions created the main codes and sub-codes. Table 2 and Table 3 show the codes, sub-codes and quote examples from the review of the documents. The main themes were created from common areas of action and main areas of change. There are 14 main themes and subsequent sub-themes (18 sub-themes) based on the airports' high-frequency and key areas of action. These results also intersect with the previous literature, common industry practices, and environmental strategies. However, the business design framework requires a more complex approach, such as stakeholder, customer, and system assessments. Therefore, while the majority of the codes supported the existing sustainability frameworks, there were also revealed themes from the analysis. For example, stakeholder and third-party collaboration, local and international regulations, or innovation factors were interconnected actions. Some of the themes might also support the other themes' success or formation. Further, there are also the regulatory actors (i.e. ICAO, IATA). Consequently, each factor is also linked to the support system and shapes the others.

Lastly, in this study, results aimed to support an exploratory and conceptual perspective instead of providing definitive or statistically significant conclusions. The target was to identify varying green initiatives, observe commonalities and challenges, and determine breaking points. And to develop guidance from the available industry and company data, rather than conduct a multi-factor quantitative assessment. Most importantly, a multi-layered approach is needed to create a conceptual model for green airports. Therefore, the themes and analysis of reports shaped the transformation framework (Figure 3).

### **3. Results**

The green business design requires a complex approach and organisational change (Chesbrough, 2007). Consequently, this study observed the latest actions in multiple areas. As mentioned in the methodological explanation, individual European airport reports, websites, public announcements, and the ACI's ACA case reports have been explored (Table 1). The analysis revealed multiple themes, and these themes were shaped by common practices that are thematically reviewed in airport operational design to minimise carbon emissions and meet sustainability targets. Results also support the gap by identifying common areas of change, such as the adaptation of common Environmental Management System (EMS) components (Sroufe, 2003) or new pain

points for the green airport transformation. As seen in Table 2 and Table 3, this study identified 14 main sustainability themes across 12 European airports and 2 Airport Groups.

First of all, airports' green actions from the operations side are clearly divided into airside and landside. For example, implementing new safety and operational processes to enhance airside efficiency (such as optimising air traffic, utilising runways effectively, and developing software) could be considered key changes in the airside operational redesign. Next, there is the business management and social side, which includes upcoming green finance and carbon calculations, leadership and marketing, stakeholder management, employee satisfaction and provision of a healthy and equal work environment, and social responsibility projects with local or international participation. Furthermore, following these actions, several thematic practice areas are grouped. Figure 2 shows this categorical division of the green airport design areas and components. These could also be further grouped as ecological impact and control (i.e., energy, noise, biodiversity, waste, water, and air pollution), social responsibility, financial management, innovation, stakeholders, collaboration, and regulations.

There is an emergence of the external environment and stakeholders, which have been integrated into the themes. The green initiatives of airports are strongly linked to external actors. For instance, there are external suppliers, third-party collaborations, local and international regulations, and technological innovations (Table 2). Thus, new sub-themes, such as regulatory representation (i.e., ACI, ISO, EU, GSSB), are introduced into the framework. Currently, regulators and trade organisations have rules, reporting systems, or accreditations (i.e., ACA, EMAS) and airports position key actions while considering regulatory and industry actors. For example, trade representatives, air transport industry regulators, or local and economic areas, such as ACI, ICAO, or the EU, implemented sustainability regulations, restrictions, carbon targets, and initiatives. These initiatives from organisations, such as ICAO, could provide support and systematic guidance in reaching sustainability targets. Every airport explored in this study adhered to ICAO's CORSIA, ACI's ACA, or EU clean aviation targets. As part of another external pressure, Europe's net-zero goal has been another recurring theme in airports' sustainability actions and targets in the analysis of reports. In reports, airports aim at minimising or controlling carbon emissions and other types of emissions. Therefore, regulatory compliance and collaboration are significant factors influencing the green airport framework. On the other hand, airports seem to develop individual projects, local or airport-based investments on a larger scale, as could be observed in the example of designing a hydrogen distribution centre at Toulouse-Blagnac Airport.

**Table 2.** Sustainability practices at airports (adapted from the analysis of reports)

Main theme	Sub-theme	Definition	Quote Example
Energy	renewable energy	Airport solar/PV installations	Naples International Airport has built a photovoltaic system to decrease the airport's dependence on non-renewable energy.
		Optimising windmills	Amsterdam Schiphol Airport utilises windmills.
	energy optimisation	Energy optimisation	Stuttgart Airport has been focusing on continuous control of energy usage.
Mobility	airport mobility	Footprint-free travel intra-airport	TAG Farnborough Airport construct bicycle roads and a fleet to use for transport between terminals.
	stations	Building electric vehicle (EV) stations	TAG Farnborough Airport installed EV stations which support GSE (Ground Support Equipment) or Tesla charging.
	strategy	Zero-emission mobility	Stuttgart Airport has been pursuing green mobility approaches.
Surface Access	transport network	Investing in public transport	Naples International Airport is investing in an underground system, which is planned to be operational by 2028.
	carparks	Green energy charging facilities	Stuttgart Airport built charging facilities for passengers and taxi drivers. The facility provides fully green energy.
Innovation	research and development	Sustainable innovations: eco-infrastructure, software development, hydrogen investment	Naples International Airport invested in the eco-heat generation plant, runway management software, and tested a hydrogen-powered prototype aircraft.
Infrastructure	hydrogen integration	Hydrogen infrastructure and distribution network	Toulouse-Blagnac Airport developed a hydrogen facility (HyPort).
		Hydrogen facilities and fuelling system, integration of robotics	Munich Airport developed robotics for the hydrogen fuelling process.
Waste	circular economy	Circular waste projects: reuse of waste	London Heathrow Airport has been developing a system to transform waste into airport furniture.
		Circular building practices	Amsterdam Schiphol Airport implemented circular building practices: circular floor covering, painting, and conveyor belt.
	recycling	Building recycling systems	Istanbul Airport focused on Advanced Waste Segregation Practices
Water	water management	Strategic water plans	AENA Group has a strategic water management plan and actions in place.
Noise	noise control	ICAO's regulations noise action plans	London Gatwick Airport follow the ICAO rules for aircraft noise in European Airports. The airport's external environment also reinforces the rules.
Biodiversity	biodiversity	The protection of biodiversity around airports	Zurich Airport developed an initiative to protect, regenerate, diversify, and improve the natural environment around the River Glatt.
Social	community engagement	Supporting the local community and society	East Midlands Airport has an ongoing financial fund for the benefit of the local community
Finance	sustainable finance	Develop a sustainable finance system and open communication	London Gatwick Airport's Sustainability-Linked Financing Framework.
	green branding	Participate in international projects, provide leadership, collaborate, and improve green branding	Brussels Airport is involved in the Stargate (Green Deal) project, providing leadership and collaborating with multiple partners.
Marketing	leadership		

**Table 3.** Sustainability regulation for airports (external environment themes).

Standards and Accreditations	ACI	Airports Council International initiatives	Airport Carbon Accreditation (2025a)
	ISO	International Organisation for Standardisation	ISO14001 - Environmental Management System (ISO, 2025) The European Union Eco-Management and Audit Scheme
	European Union	European Commission initiatives and standardisations	Corporate Sustainability Reporting Directive (European Commission, Directorate-General for Environment, 2025a)
	GSSB	Global Sustainability Standards Board	Global Reporting Initiative (2025)
Guidance and Collaboration	ICAO	Carbon Offsetting and Reduction Scheme for International Aviation	CORSIA monitoring, reporting and verification system (ICAO, 2017)
	United Nations	Provision of a regulatory framework	United Nations Development Programme (UNDP, 2025)
	European Union	Support for green transformation Collaborative platforms	Other European Commission regulations and schemes for air transport

Consequently, it is possible to emphasise that businesses (e.g., airlines and airports) and other industry stakeholders comply with sustainability regulations and goals, while industry initiatives guide and support the transformation process. Another crucial aspect is energy use, resource efficiency, electrification of operations, and integration of green energy. Airport operations are dependent on energy, which has led to energy use becoming another area of focus in green business. Naples International Airport is building photovoltaic systems, and Amsterdam Schiphol Airport is utilising wind power, which are some examples of these implementations. ACA presented that the first stage of accreditation could start by renewing the existing infrastructure or systems, stopping energy waste, and increasing airport energy efficiency (Airport Carbon Accreditation, 2025a). Further, according to the latest research in both academia and industry, high-efficiency engines, infrastructure or system design, and hydrogen storage options must be assessed further (Alexandrou and Khatiwada, 2025; Ayar et al., 2025; Suwaileh et al., 2025). These transformations are additionally categorised under the innovation theme. This theme appears to be supporting the sustainability goals. Specifically, the air transport industry and researchers accepted hydrogen as a possible alternative energy source for aircraft or other airport ground equipment. However, these might require new infrastructure or service designs for airports, as mentioned. For example, Toulouse-Blagnac Airport planned special storage and high-technology loading infrastructure (i.e. robotics) and equipment for hydrogen service. Additionally, according to the airport report, this plan is seen as a significant development opportunity for a regional-scale hydrogen adaptation.

Alongside these practices, the combination of green energy initiatives and new surface access strategies has been developed for landside design, such as expanding public transport options, adding electrical charging

stations for private cars, and installing alternative green energy infrastructure in parking areas. For instance, private car access is supported with designated charging points for electric vehicles and green energy supplies, as seen at Stuttgart Airport. There is also the terminal and intra-airport mobility examples, such as using electric vehicles for both staff and passenger transport on the airside or the provision of a cycling option. The majority of airports explored in this study supported the green surface access design, initiated new public transport developments, and invested in green energy for electric vehicles, such as NAP and STR examples.

Moving beyond operations, there is also the social side to the sustainable airport design. Airports' sustainability actions are included in the Corporate Social Responsibility (CSR) framework or published in annual reports. A good example of this is the ongoing community fund at East Midlands Airport (EMA), which has been supporting the social side of the sustainable transformation for years. EMA's social support approach, local engagement, collaborations and community engagement strategies have been guided and similarly applied by airports owned by the Manchester Airport Group in the UK. Another theme is sustainable finance, which has been a recurring area in reports and public announcements about airport planning. Due to ongoing research and development, or operational redesign, companies might require investment support for transformation. There are also developing regulations, tax systems, and multiple climate or cost-related risks to consider for the future. For instance, London Gatwick Airport (LGW) prepares a strategic planning report on the company's sustainability-linked financing framework. LGW planned clear guidance for sustainability-related investments, loans, or bonds, which support the maximum utilisation of the available finance. Most importantly, Kumar et al. (2025) support that airports could be productive while benefiting from available

finance through these options.

Taken together with the preceding findings, it is important to highlight that communication and transparent reporting have been observed, with annual reporting. There are also special reports for corporate social responsibility, sustainable transformation and yearly progress. These reports or public statements disclose the latest action, net-zero targets, and provide updates. The majority of the airports in the sample have a common planning approach and dynamic systems in place for each area of operations and business transformation. These are published to inform the public and external stakeholders. Additionally, the hub airports, airport groups, and impactful or private regional airports are actively publishing reports, collaboration news, or public statements. There is an evident effort by airports actively share the effectiveness of actions that provide transparency and inform stakeholders.

There are both common and diverging areas in the implementation of green practices between airport categories. Table 4 presents 3 different airport categories: hub airport, regional airport, and airport group. In the assessment, interlinking factors or strategies appear in areas of green actions across

selected European airports. For example, Istanbul Airport have an open reporting system and actively follows sustainability frameworks. This hub airport's sustainability report provides an in-depth view of the green transformation progress, key actions taken to reach the current stage, and future targets. There is an integration of the main sustainability frameworks: EMS, ESG, and CSR. The utilisation of the technological innovation theme through sustainable digitalisation in terminal operations, waste management, or building infrastructure for electrification and hydrogen. LHR, which is another major European hub airport, also has a similar strategic framework. In addition to the Manchester Airport Group reports and sustainability actions. On the other hand, regional airports are also following a steady transformation process and aligning operations with the regulatory environment. In terms of ACA levels, infrastructure redevelopment, innovative investments, and social projects present different levels of progress. Overall, regional airports utilise available sources to maximise green transformation, while hub airports and airport groups position businesses as leaders in the development of green transformation.

**Table 4.** Sustainability approach and airport models (adapted from the analysis of reports).

Airport Category	Sustainability	Example Airports
Hub Airport	-High-level environmental action execution (major ACA and accreditation success).	IST LHR BRU
	-Open documentation, reporting, informing the public.	
	-Green branding and marketing.	
Regional Airport	-Sustainability leadership and collaborations.	EMA NAP STR
	-Invest in industry-wide green energy developments and innovation.	
	-Completed the fundamental sustainable strategies and are in the process of development.	
	-Airports with strong business (regional significance, high traffic) have the same ACAs as large airports.	
Airport Group	-Adapted strong local social sustainability strategies.	AENA MAG
	-Some might have limited innovation-based investment (might be due to capital limitations).	
	-Open documentation might depend on the ownership.	
	-Airport Groups unify legal, sustainability, or social management under the portfolio of airports.	
	-Airports operating under the group have a structured sustainability approach.	
	-Follows a group-wide strategic sustainability framework.	
	-Documentation, reporting, informing the public (both group level and individual airport projects).	
	-Individually, airports could present diverse actions or progress. For example, different ACA levels.	
	-Invest in industry-wide green energy developments (i.e. hydrogen) and innovation.	

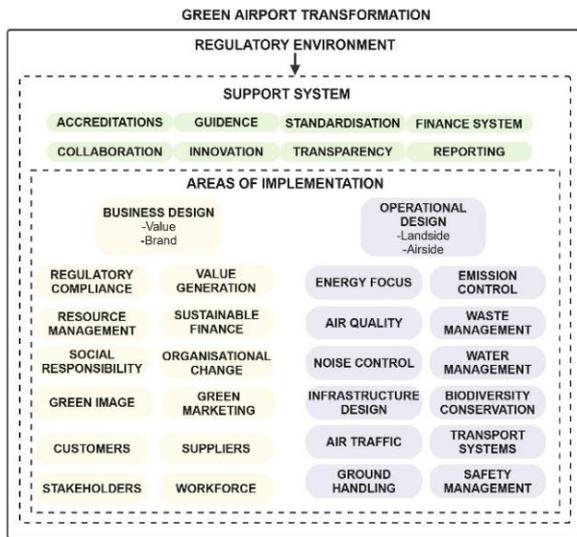


Figure 2. Green Airport Transformation (designed by the author).

Lastly, Figure 2 shows the grouped areas of implementation for designing green business collected from the literature review and reports. This figure incorporates existing and revealed areas for green transformation. Some of these areas have been explored individually in ICAO’s airport sustainability-based toolkit. However, in this figure, a broader visualisation is provided for certain sustainability steps, and additional

areas are incorporated for the ultimate design process. For instance, the external business environment, green image, sustainable finance, support system, and collaboration. As explained, these are common and frequently occurring airport practices and are deduced from the findings. To sum up, airports are driven by multiple factors in the efficient integration of a green business model. It is significant to acknowledge the involvement of the complex actors and areas. Thus, exploration of the conceptual frameworks could support future implementations.

4. Discussions

This study presents an assessment of the current airport sustainability practices and ongoing green transformation actions. The results highlighted key points of practice and revealed common steps to build a green airport business.

The thematic analysis of selected airport reports provides converging areas, confirms the best practices and incorporates revealed areas into the guidance system. For instance, Figure 3 supports the understanding of the broader business design aspect, and Table 1 presents ongoing actions to transform and achieve greener airport operations.

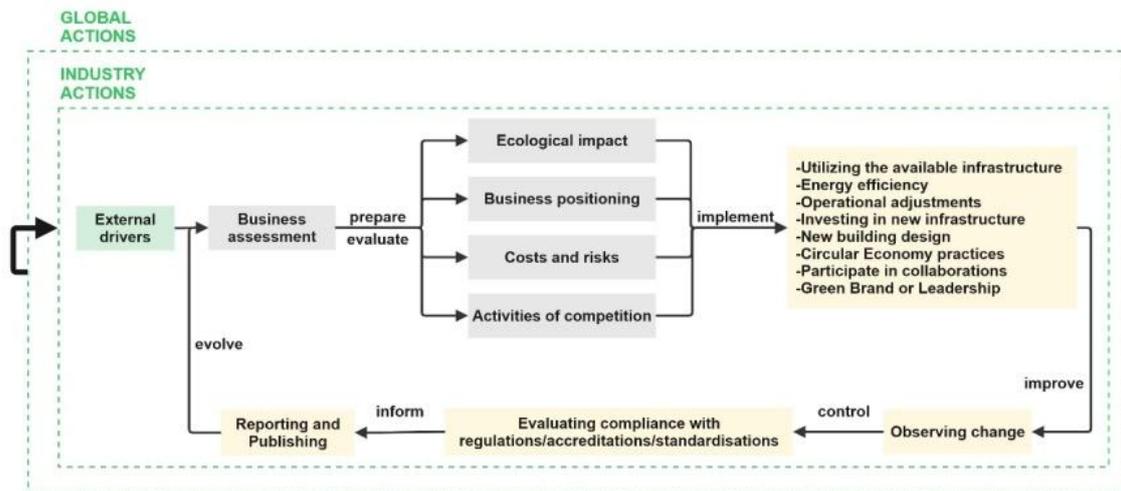


Figure 3. Framework for a Green Airport Model transformation (designed by the author)

Based on the actions and plans of selected airports, it is possible to suggest that sustainable practices and airport business decisions are influenced by the combination of the regulatory environment, environmental impact levels, and airport characteristics. Furthermore, businesses are expected to undergo operational transformation and redesign business strategies in the upcoming market conditions and sustainability regulations.

First, regulatory drivers and trade organisations have rules, reporting systems and accreditations (i.e. ACA, EMAS). Fundamentally, airports adhere to the regulatory

environment and global standards, such as ISO 14001. This standardisation provides assessment criteria, models, and guides the green transformation in various operational areas (ISO, 2025). Also, initiatives from organisations such as ICAO provide support and systematic guidance in achieving the sustainability targets through systems such as CORSIA (ICAO, 2019). ACI is another significant stakeholder in guiding airports in creating carbon-neutral operations, providing accreditations, assessment criteria, and a verification system. This initiative also shows that airports are changing to meet the expected targets and control

emission levels on an international scale (Airport Carbon Accreditation, 2025a). In the ACA system, airports are currently at different levels according to transformation progress, while the aim is to create the most controlled and reactive business structure. As a first step, airports utilise the available infrastructure to achieve sustainability goals (i.e., carbon-neutral operations, energy savings, or green energy generation). Thus, the ACA program requires fundamental changes such as financial investment, examination of the carbon impact and control, and new equipment or facility design (Dissanayaka et al., 2025). It is possible to suggest that providing these initiatives and guidance has contributed to taking the first step or designing advanced sustainable airport operations. This could be a significant highlight for airport operators in achieving sustainability targets. Mańkowska et al. (2023) also suggested that regulations encourage positive change for airports. The findings had been similar in the study sample due to the regulations either restricting airport actions, such as noise or supporting and enabling financial support or collaborative initiatives, such as the Stargate programme at Brussels Airport.

Alongside the regulatory framework, another theme is the collaboration and support systems. The airport practices, as seen in Table 2 and Table 3, include other industries (i.e. energy, technology), global or industry organisations, and external regulators that are also part of the transformation. For example, supported by the UN, EU (e.g. Horizon Europe), and sustainability agreements between countries (e.g. Paris Agreement), there is increasing financial support, funding, and knowledge sharing for the projects aimed at developing new green or energy-efficient innovations (e.g. green aviation) (European Commission, 2021). Currently, the air transport industry demonstrates wide-ranging collaboration, reactive actions, and support systems at a high level. Following the examples of sustainable transformation, it is reasonable to suggest that providing external support systems guides airports in designing sustainable businesses. Airports tend to apply annual planning, systematic reporting (conducted by the airport's management and external sustainability analysts), inform the public, invest in innovation or participate in collaborations, while following industry and local regulations.

Next, there was the redesign of airport facilities and operations to utilise existing or new areas and facilities to integrate green energy systems. The surface access theme is one of these. The goal of sustainability practices related to car parks and surface access is to create convenient, accessible, effective, and low-carbon transport systems to and from airports. The majority of this study's airports either designed electric car parking facilities using green energy or improved public transport accessibility to the airport. Moreover, the industry and airports are investing in electrical equipment (i.e. ground handling vehicles)

(Pramuanjaroenkij and Kakaç, 2023), renewable energy applications to improve the cost of energy (Koroneos, Xydis and Polyzakis, 2010), or hydrogen as an alternative energy source to achieve lower carbon emissions and less dependency on fuel (Braun and Classen, 2023; AZEA, 2024). The exploration of hydrogen as an energy source is a popular area in the air transport industry. Braun and Classen (2023) highlighted that designing a new supply chain for hydrogen integration at airports is significant. For example, preparing and utilising available airport areas for a station, transport roads, and parking slots for new equipment around revealed safety needs. It is possible to observe this from the Toulouse-Blagnac Airport case, as the airport integrated and planned a hydrogen distribution centre while reconsidering road access and planning a regional distribution. Similarly, research on energy efficiency lists renewable energy generation as a significant part of airports' transformation (Koroneos, Xydis and Polyzakis, 2010). Further, Khalil and Dinçer (2024) assessed a system that combines multiple renewable energy generation. Similarly, after the exploration of airport reports, the findings indicate significant investment toward the utilisation of available green energy sources (i.e. solar power, wind) and infrastructure development for this goal. To sum up, while hydrogen integration continues to be an idea or in development, airports continue to prioritise alternative and renewable energy sources in operations, as observed in the case examples.

Finally, these deductions and thematic review align with prior research, indicating that the applicability of the new business design could be assessed by observing individual areas of a business (Antikainen and Valkokari, 2016; Joyce and Paquin, 2016; Bocken, Boons and Baldassarre, 2019). Consequently, it is possible to suggest that the first step in creating a sustainable business is assessing the individual company's operations, systems, and infrastructure potential. The overall goal has been consistent, with airports prioritising the assessment and redesign of their operations to achieve efficiency, adopt new technologies, implementing innovative practices and creating a sustainable system that aligns with the new regulatory environment. Further, technology and investment in innovation, collaborative approaches, business potential assessment, financial support, and individual sustainability plans, as well as the determination of goals and achievable actions to fit the changing global business and market environment. Overall, the study's results could be interpreted as the green airport concept and business transformation were enabled through the systematic implementation of these complex factors.

## 5. Conclusions

Climate change issues have become a crucial turning point for the world due to the increasing problems related to the ongoing and upcoming nature crisis. Businesses focus on shaping resilient and sustainability-

oriented organisations to overcome new challenges. The air transport industry's market conditions have also been changing, and airport operations are expected to face operational challenges due to climate change issues. Currently, the aviation industry and airports are also following carbon-neutral goals and plan targets to reduce carbon emissions. Thus, airports need to meet the demands of local and industry regulators, which will require organisational transformation at the multi-level business structure. For instance, finance, operations, stakeholders and relationships, logistics, energy management, safety and security. Consequently, developing green practices and adapting new sustainable systems to achieve business model change has been an ongoing process in the air transport industry.

Most importantly, there has to be a separation of strategy from business model. This creates confusion in studies and industries, as the research either misses crucial areas or downplays certain aspects, focuses solely on strategic development, or combines and mismatches available frameworks. Thus, it is essential to emphasise that a sustainable strategy is not equivalent to a green business model. From a system-level perspective, this study indicates that the multiple sustainability strategies shape the green business model. There are common sustainability frameworks; however, each of these targets to cover specific pain points or problems. Further, the aim is to achieve an efficient and safe operational transition to a sustainable airport.

The business model transformation changes the internal business structure, disturbs the existing operations, creates partnerships, and incorporates new dynamics. In green business design, airports should understand the existing airport model, value and business structure, infrastructure, stakeholder needs, investment capabilities, social impact potential, areas for further investment, and external environment expectations. Additionally, balancing each factor is important to minimise risks, control investment costs, protect market share, and enhance operations and efficiency (Figure 3). The balanced approach supports well-grounded transformation and enables the design of efficient new green business operations.

Due to the distinct nature of operations and management, green transformation efforts involve diverse stakeholders, investments, infrastructure, and procedures. In practical terms, this means that green business model design is complex and requires multiple themes to be considered to shape the best practices, successful transformation and become the industry-leading example. As observed from the results, airports shaped targets on time, provided plans for certain periods, diligently observed progress, and revised actions accordingly. Taken together, the results demonstrate that the Green Airports rely on complex factors and coordination of these factors (Figures 2 and 3).

It is important to emphasise that the green business concept cannot be achieved solely by copying certain

frameworks, systems, or developing a strategy within limited areas. The internal business assessment is the first step towards redesigning operations. It aims to understand the level of environmental impact (such as carbon or water footprint), plan for change, and meet the expectations of regulators, customers, and suppliers. In Table 2, Table 3 and Figure 2, it is possible to see the key components and implementation areas for sustainable change at the operational level (such as noise control, water management, and waste management). An effective internal assessment might also enhance financial viability and efficiency, as it may be part of the process of creating an efficient organisation. On the other hand, there are multiple challenges in implementing green airport business practices. For example, operational or infrastructural changes might require significant investment. Airports also consider long-term outcomes, societal influence, and partners in change. While the strategy guides the business, the business model requires fundamental transformation and innovation.

Currently, airports are working towards a sustainable market design. After examining industry practices, it is clear that airports and regulatory bodies have been developing support chains that facilitate ongoing system change. Both global and industry actors drive and support organisational change simultaneously. Therefore, businesses could benefit from considering the constantly evolving environment and a wide range of industry stakeholders in airport plans. Most importantly, the overall transformation could depend on and be led by the system's development. Consequently, the environment in which airports operate is also a determining factor in the success of the green business transformation.

To sum up, there is still confusion and guidance issues on the systematic integration and management of green businesses. There is a mix of local, country, and international regulations, technology, innovation, knowledge sharing, key stakeholders or new partners, and financial factors. The integration of each of these in a framework could support the efficient transformation and design (Figure 3). These factors could also be unstable or change over time, which requires the framework to be scalable, resilient to external impacts, and dynamic. The examination of selected current airport practices in Europe shows an increasing focus on green innovation and transformation. Thus, this study supports future research by providing an updated and design-based outlook on airports and a conceptual framework for green airport business transformation.

### **5.1. Limitations and Future Research**

The sample size, a single coding approach, and no periodic analysis could be listed as limitations of this research. In some situations, reliance on one market (Europe) could also be listed as a limitation. Therefore, further studies could incorporate different factors to overcome these limitations. For example, a survey on a

specific airport market could reveal more actions and represent the market. Future studies could also incorporate airports worldwide, focus on specific time periods, or apply alternative statistical methods to shape new metrics on the green airport concept. On the other hand, from this study's framework and review, guidance materials could be further developed, and a standard model could be created. It is expected from academia and industry to advance the green business transformation processes.

**5.2. Conceptual Framework for Green Airports**

Previous studies included or explored certain global frameworks such as CSR, ESG, EMS, or mainly focused on the sustainable strategies. There is also continuing confusion between a green strategy and green airport concepts. Furthermore, the green transformation is still a developing area both globally and for the air transport industry, while the regulatory environment is also in the development stage. Airports currently focus on standardised approaches in addition to employing diverse strategies to control emissions, conserve energy and achieve their objectives for generating green energy. Thus, this work aimed to provide an outlook on the green airport transformation for the selected European airports with diverse business characteristics. The study could be beneficial by providing an informative review of the gaps and actions, while suggesting a simplified transformation framework for guidance to both academia and industry.

**Author Contributions**

The percentages of the author' contributions are presented below. The author reviewed and approved the final version of the manuscript.

	O.C.
C	100
D	100
S	100
DCP	100
DAI	100
L	100
W	100
CR	100
SR	100
PM	100
FA	100

C= concept, D= design, S= supervision, DCP= data collection and/or processing, DAI= data analysis and/or interpretation, L= literature search, W= writing, CR= critical review, SR= submission and revision, PM= project management, FA= funding acquisition.

**Conflict of Interest**

The author declared that there is no conflict of interest.

**Ethical Consideration**

Ethics committee approval was not required for this study. The data/information used in this study is publicly available and could be accessed through industry organisations and company websites. Additionally, this study has not been previously published or submitted for publication.

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