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GREEN HORIZONS AHEAD: NAVIGATING CARBON NEUTRALITY IN EUROPEAN TRANSPORTATION BY SKY AND SEA

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Abstract

Research purpose. As carbon neutrality gains momentum, industries worldwide are navigating the challenges and opportunities posed by sustainability goals. This article delves into the strategies undertaken by airlines and maritime companies to achieve carbon neutrality by 2050 in the European Union (EU). The aim of the research is to explore how the aviation and maritime industries in Europe can effectively transition towards carbon neutrality by 2050, considering their similar technological challenges and opportunities. The objective of this research was to identify and compare currently utilized sustainability initiatives in aviation and maritime companies. The focus is on new insight from airline and maritime companies concentrating on their sustainability practices. Common hurdles, innovative solutions, and shared opportunities in the pursuit of environmental sustainability are explored.

Design / Methodology / Approach. The selected research method was qualitative research, which was conducted with in-depth and semi-structured interviews and content analysis. Interviews were conducted with airline company and association representatives and maritime company, research, and education experts. The content analysis was based on sustainability reports and sustainability sections of annual reports. Key findings were synthesized into a theoretical framework and this research explores practical initiatives for a sustainable transformation process.

Findings. The call to reduce carbon emissions has been initiated by the EU affecting the transportation sector, particularly aviation and maritime industries where the path to achieving carbon neutrality is constrained by significant technical limitations. Despite these challenges, both sectors share a unified objective according to EU climate targets. Both the aviation and maritime industries face challenges on the path to carbon neutrality. Airlines struggle with the limitations of current aviation technology, hindering the feasibility of large-scale technological advancements. Similarly, maritime companies confront regulatory complexities and infrastructure limitations in the adoption of alternative fuels and emission-reduction technologies since the commonly used tactics of reducing fuel consumption by optimizing speed, routes and scheduling are no longer adequate ways and the energy needs of the shipping industry cannot be met only with battery technology.

Originality / Value / Practical implications. These challenges offer opportunities for innovation and collaboration. Investments in research and development are driving advancements in electric and hydrogen aircraft, while the maritime industry is also trying to find hydrogen-based solutions for greener development, but the technologies are not widely available. This leads towards combining bio-oils and technological innovations related to the fleet. Case study 1 sheds light on airline sustainability in Europe, revealing strategies and initiatives that European airlines are currently utilizing in their sustainable transformation journey. Case study 2 explores different means of achieving carbon neutrality in the maritime industry, in particular the potential of common reed (Phragmites australis) as a carbon offset tool for reaching net zero. Both industries are making significant strides towards carbon neutrality through a combination of technological innovation, operational efficiencies, and strategic partnerships. Towards green horizons as transport industries converge on the path to carbon neutrality.

Keywords: carbon neutrality, aviation, maritime, green transition, sustainable fuels.

JEL codes: Q5, R4.

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Introduction

Air travel stands out as a prominent contributor to climate change, responsible for approximately 3.5% of the world's total CO2 emissions (Ritchie, 2020). With a commitment to achieve carbon neutrality by 2050, airlines are tasked with the formidable challenge of transitioning nearly three decades of operations towards sustainability. While the aviation sector often attracts significant attention, it is crucial not to underestimate the impact of the maritime industry on climate mitigation efforts. In 2022, global maritime transportation contributed roughly 2.8% to the total CO2 emissions worldwide, according to data from the International Maritime Organization (IMO, 2022). The maritime sector is slower to react and change than the aviation sector, also in terms of green transition. Renewable gasoline like biofuels or biogas are now good alternatives for fossil fuels since hydrogen is not yet a solution as the technology is not yet sufficiently developed that it would be commercially viable.

Acknowledging this significant impact, the IMO updated its emissions mitigation strategy to adhere to ambitious objectives aimed at attaining carbon neutrality in the maritime sector by 2050 (IMO, 2023). This commitment mirrors the emission reduction targets set by the EU, underscoring the maritime industry's significant role in global efforts to combat climate change. In parallel to aviation, the maritime industry also struggles with its environmental footprint. Ships release greenhouse gases and other harmful pollutants, further worsening climate change and marine pollution concerns (IMO, 2022). Like their counterparts in aviation, maritime companies are also actively pursuing strategies to achieve carbon neutrality according to the EU's carbon neutrality targets (European Commission, 2024).

The aviation and maritime industries were selected to represent the European transportation industries in this research as two of the authors have extensive backgrounds working in aviation and maritime companies as well as having a thorough understanding of the industries. The authors' professional interest and existing networks steered the perspective of the research to aviation and maritime industries and therefore other transportation industries were excluded from this research.

In this research, the authors investigate the impact of prominent phenomena and trends on the perspectives of the airline and maritime industries in Europe. SITRA is a Finnish, independent, research-oriented, and governmentally supported innovation fund, which creates a review of megatrends on a yearly basis. SITRA megatrends provide an exhaustive overview of the dynamic forces shaping change, including nature, people, technology, power, and economic factors, which collectively exert significant external pressures on both sectors (SITRA, 2024). Global warming emerges as a pivotal megatrend affecting both industries, aligning with international agreements such as The Paris Agreement and initiatives like the European Green Deal and Fly Net Zero by 2050 (Paris Agreement, 2015; Council of the EU and the European Council, 2024; IATA, 2024). From the maritime industry perspective, a significant regulatory body is the International Maritime Organization (IMO), while The Integrity Council for the Voluntary Carbon Market (ICVCM) plays a crucial role in voluntary offsetting efforts, particularly in the evolving landscape of emission offsetting (Integrity Council for the Voluntary Carbon Market, 2024). The aim of the research is to explore how can the aviation and maritime industries in Europe effectively transition towards carbon neutrality by 2050, considering their similar technological challenges and opportunities. The objective of this research, which was based on the two case studies, was to identify and compare currently utilized sustainability initiatives in aviation and maritime companies. The focus of the research is on new insight from airline and maritime companies, and this has influenced on selection of the interviewees and reports utilized. Calculating the carbon emission was not included in this research. Aviation industry initiatives were studied based on airline company and association representatives' interviews, sustainability reports, and sustainability sections of annual reports. The maritime industry-related general initiatives were studied based on literature reviews and maritime industry associations' reports. Through qualitative research encompassing semi-structured interviews with airline experts and thematic content analysis of sustainability reports; and a qualitative case study from the maritime industry based on expert interviews of the potential of utilization of common reed biochar as a voluntary credible and ethical carbon offsetting tool, this research aims to capture the complexities of sustainability initiatives in both aviation and maritime sectors. By synthesizing key findings into a theoretical framework, the research seeks to inform practical recommendations and tools to facilitate the sustainable transformation process. Ultimately, by

adopting a holistic perspective that encompasses both aviation and maritime industries, this study aims to provide a practical view of sustainability challenges and opportunities in European air and sea transportation.

The authors recognize that utilizing information based on the interviews of the company representative and companies' sustainability reports might create a bias. However, to reduce the bias an interview was conducted with a sustainability expert from the aviation association, confirming the findings from the other interviews. In addition, the aim of the research was not to evaluate the level of the carbon emissions produced by the European aviation or maritime industries, nor the level of sustainability of the companies, but to explore and compare the current sustainability initiatives utilized by the companies. The authors estimated that the best insights to produce this new information would be through the companies' sustainability representatives and reports. The selected maritime case company had already utilized the current mitigation methods available, and this study concentrated on the opportunities for achieving net zero through voluntary carbon offsetting with common reed. As the best practices for utilizing common reed are still under development the objective of the case study was to gain new knowledge. Accordingly, the selected research methods were in-depth and semi-structured interviews of the experts on the field from education and research, from public organizations and companies.

Reducing fossil fuel usage and finding alternative sustainable fuels to replace them is a key initiative for both sectors in achieving carbon neutrality. In addition, corporate social responsibility (CSR) and waste management are other significant areas of improvement for both sectors not only to enhance sustainability but also from the perspective of current cost-saving opportunities. (CSR Europe, 2024; IATA, 2024; IMO, 2023.) Furthermore, the integration of the United Nations Sustainable Development Goals (SDGs) into sustainability strategies has become essential in directing efforts toward global sustainability objectives encompassing social, economic, and environmental sustainability (Hajian & Jangchi, 2021). The SDGs offer a comprehensive framework that allows airline and maritime industries to align their sustainability initiatives with internationally recognized goals (United Nations, 2024). When delving into SDGs within the maritime industry, there is a linkage to the concept of the "Blue Economy," which pertains to the ocean or maritime economy striving to enhance human and societal well-being while concurrently mitigating risks to the environment. The idea is to align economic development with ocean health and focus on sustainable ocean areas. (World Bank and UN Department of Economic and Social Affairs, 2017).

By examining sustainable transformation efforts through challenges and opportunities, this study sheds light on the multifaceted approach required for both the airline and maritime industries. From the perspective of the airline industry, the focus is on CO2 emissions reduction, organizational development, and competitive advantage, while some in the maritime industry emphasize correct and ethical voluntary carbon offsetting, utilizing common reed. Drawing on research on climate change (Romm, 2022), Fiedler's contingency theory (Donaldson, 2001; Luthans & Stewart, 1977), Porter's competitive advantage (Porter, 1985), companies' understanding of the use of carbon credits (Trouwloon et al., 2023), technologies for achieving carbon neutrality (Xu et al., 2023; Wang et al., 2021), and consumers´ perspective on emission reduction and carbon offsetting (Roemer et al., 2023; Wang et al., 2020), the research aims to uncover valuable insights that can drive meaningful change for the European transportation industry.

Xu et al. (2023) analysed carbon neutrality research from 2000 to 2022, noting a significant increase in publications between 2020 and 2022. They found variations by region, with the US and China leading. Research focused on practical, technical, policy, and economic aspects, with renewable energy, carbon capture, and carbon conversion technologies as key areas of interest. Furthermore, Wang et al. (2021) examined technologies and strategies for attaining carbon neutrality. Their findings suggest that the current trajectory falls short of achieving the climate neutrality goal by 2050 unless crude oil and coal development ceases by 2021. Urgent action is required to overhaul the energy sector, necessitating cutting-edge research and interdisciplinary collaboration in technology, civil and environmental engineering, and the integration of bio- and nanotechnology.

Carbon neutrality goals set by companies globally have garnered attention as crucial measures against climate change. Trouwloon et al. (2023) investigated companies' comprehension of carbon credit utilization, emphasizing the importance of clarity and transparency. They identified three key dimensions: understanding the purpose of carbon credits, comprehending the differences between carbon neutrality and net-zero claims, and discerning between achieved milestones and aspirational targets. Roemer et al. (2023) studied consumers´ views on emission reduction and carbon offsetting and discovered that consumers are willing to pay more for the lower carbon footprint of a service.

Previous research from Nyamdorj et al. (2021) supports the authors´ topic of the aviation industry achieving carbon neutrality. The study discusses the establishment of CORSIA and Airport Carbon Accreditation, which are programs that impose carbon management obligations on the aviation industry. The research by Nyamdorj et al. (2021) emphasizes the training product to be presented that will clarify how to go beyond mere compliance and exceed the carbon reduction requirements of these instruments by achieving carbon neutrality in operations. This is closely related to the authors' study on how the aviation industry can reach carbon neutrality by 2050. By adopting sustainable practices such as operational efficiency improvements, the use of sustainable aviation fuels, and investments in carbon offsetting projects, the industry can significantly reduce its carbon emissions.

Furthermore, the study from Brazzola et al., (2022) investigates climate-neutral aviation by jointly capturing the CO2 and non-CO2 effects of aviation and combining them with scenarios of demand and technological change. The research underscores the challenge of reconciling rapid aviation growth with climate goals post-COVID-19 and emphasizes the need to address both types of emissions for climate neutrality (Brazzola et al., 2022). This study concentrates on efforts on how the aviation sector can reach carbon neutrality by 2050, providing measurement insights that complement the strategies outlined in the authors' article on sustainable aviation practices.

Parallels can be drawn between sustainability challenges and initiatives in the maritime sector and those in the aviation industry. Like the aviation sector, maritime companies across Europe are increasingly acknowledging the imperative to tackle environmental issues and diminish their carbon footprint. Consequently, there has been a heightened focus on enhancing energy efficiency, embracing sustainable fuels, and investigating innovative technologies to accomplish emission reductions within the maritime industry. These efforts align with broader global sustainability goals and demonstrate the industry's commitment to mitigating its environmental impact while ensuring the efficient movement of goods across Europe's seas (European Commission, 2024; IMO, 2022).

In this study, the selected case company related to the maritime industry is already well advanced in sustainability initiatives and thus voluntary carbon offsetting is considered a solution for reaching entire carbon neutrality after all the mitigation has already been done using biofuels. According to Boyle (2021), voluntary carbon offsetting presents challenges as selecting offsetting as a key element for achieving the climate goals has led to according to a situation where polluters have been allowed to continue polluting by buying and selling permits to pollute, and due to that concentrating on cutting emissions has been neglected. Furthermore, it has been noted that misleading assertions have adversely impacted the reputations of companies, as highlighted by recent research (Trouwloon et al., 2023). Regarding voluntary offsetting, there is currently a lack of standardized regulations, with only recommendations in place. According to recent studies (Laine et al., 2021), credible and ethically sound emission offsets should adhere to internationally established criteria, encompassing elements such as additionality, a robust baseline, rigorous calculation methodologies, comprehensive monitoring and reporting mechanisms, stability, avoidance of carbon leakage, authenticity, transparency, certifiability, prevention of double counting, and mitigation of significant harm (Finnwatch, 2024; Laine et al., 2021). Additionally, like airlines, maritime companies also face pressure from regulatory bodies and consumer expectations for sustainable practices (European Commission, 2024).

Research Methodology

The research methodology for this study employed a qualitative approach. Qualitative research was chosen for its ability to offer valuable insights into real-world problems, exploring participants' experiences, behaviours, and perceptions (Brannan et al., 2017).

The research methodology for the airline case study comprised semi-structured qualitative interviews with airline sustainability experts. These interviews delved into areas such as CO2 emissions reduction, organizational development, and competitive advantage through sustainability initiatives. Thematic content analysis was subsequently employed to analyse the interview transcripts, guided by theoretical frameworks including climate change theory (Romm, 2022), contingency theory (Luthans & Stewart, 1977), and competitive advantage theory (Porter, 1985).

Semi-structured interviews were conducted with airline sustainability experts to gather diverse perspectives and comprehensive data on the research topic. These interviews followed a predetermined set of questions and were facilitated in a participant-observer format to ensure open discussion while minimizing researcher influence. Three airline sustainability experts and one airline association sustainability expert were interviewed. These interviews were conducted between September 2023 and October 2023. The candidates contacted were selected based on their LinkedIn profile stating that they have sustainability roles either in European airline, airline group or airline association and the interviewees were selected based on voluntary participation. (Pimiä, 2023) The interviews were conducted virtually, with the interviewer maintaining reflexivity to mitigate bias. Ethical considerations were upheld, ensuring participant confidentiality and informed consent. Despite the limited number of interviews, data saturation was achieved, indicating the sufficiency of data for analysis. The findings contribute to understanding sustainability practices within the European airline industry. (Pimiä, 2023)

Additionally, two individual annual reports from Norwegian Air Shuttle and EasyJet were examined together with the sustainability reports from four major airline groups: the Air France - KLM Group, the IAG Group, the Lufthansa Group, and the Ryanair Group. These reports provided valuable insights into sustainability practices within the European airline industry. The purpose of the data sampling strategy was to collect as comprehensive sustainability information as possible from the majority of European airlines. Airline groups and individual airlines were selected by the author based on her knowledge of the airline industry. The airline sampling included different flagship and low-cost carriers, individual airlines, and airline groups from different European countries. (Pimiä, 2023)

A phenomenological approach was applied to investigate the effects of climate change on European airlines, aiming to comprehend these impacts from individual perspectives. Thematic content analysis was then employed to identify recurring themes in interview transcripts and sustainability reports obtained from European airlines. (Anderson, 2007) This analysis provided practical insights into sustainability initiatives applied across the industry. The data collected from interviews and sustainability reports were organized and coded manually in an Excel spreadsheet as datasets.

Furthermore, a maritime industry case study was incorporated, employing qualitative research methodologies (Mahoney & Goertz, 2006; Urponen, 2023), which allow for in-depth exploration of specific research problems. Individual cases are usually at the centre of the qualitative research method, (Eriksson & Kovalainen, 2016), making it suitable for investigating topics that cannot be adequately addressed through numerical data or large sample sizes. Given the innovative nature of the research topic and the limited expertise available in the selected region, qualitative methods were deemed appropriate for this study.

The interviewed participants for the maritime case study were selected based on their specific knowledge about the common reed, their interest in it, or their expertise in voluntary offsetting. The qualitative data collection methods used were semi-structured and in-depth interviews. The interviewees provided both organizational and corporate perspectives and came from various sectors: maritime, innovation, research, and offsetting. The organizations represented included the University of Turku, Turku University of Applied Sciences, John Nurminen Foundation, Business Turku, NGS Finland, and Meriaura Invest. The interviews were conducted in two phases. The first round took place face-to-face with three experts on April 24th, May 17th, and May 19th, using an in-depth approach.

The second round of interviews was held virtually via Teams from November 10th to 16th, 2023, involving six experts. These interviews were conducted in Finnish using a semi-structured approach, where the same set of predetermined questions was asked of each interviewee, though they had the freedom to discuss related topics as well. The questions were originally in Finnish, focusing on the interviewees' background with common reed and the arguments for using common reed from both

offsetting and general perspectives. Each interview was recorded, transcribed into Finnish, and then translated into English. During data processing, recurring themes emerged from the responses, which were coded to outline the main themes. (Urponen, 2023)

By examining both airline and maritime industries, this study aimed to provide a holistic understanding of sustainability efforts in European transportation in the selected industries. Overall, these research method approaches comprehensively examined sustainability efforts within both the airline and maritime industries, providing practical insights into organizational initiatives and industry trends.

Results

The research findings (Pimiä, 2023; Urponen, 2023) related to sustainable transformation based on European airline expert interviews or reports and maritime industry expert interviews unveiled significant challenges and promising opportunities. Common challenges, including technological limitations, regulatory pressures, and customer scepticism, posed hurdles to achieving carbon neutrality for both industries. However, initiatives such as Single European Sky (SES) implementation (European Commission, 2024) and investments in Sustainable Aviation Fuel (SAF) production offered solutions to reduce CO2 emissions for airlines, while similar measures regarding sustainable fuels and utilization of common reed as a tool for voluntary carbon offsetting were explored in the maritime sector. Collaborative efforts with stakeholders were found crucial in supporting both industries to meet sustainability targets. Despite challenges, numerous opportunities emerged, including the adoption of sustainable business models, transparent communication, and early investment in pursuing sustainability leadership. These strategies were seen as avenues to establish long-term competitive advantages in sustainability. Shared research findings from the contribution of the airline experts and reports (A), and maritime experts (M) can be seen below (Fig. 1).

RESEARCH RESULTS	THEME 1 CO2 Emissions	THEME 2 Organizational Development	THEME 3 Competitive Advantage
Initiatives	• Increase use of sustainable fuels (A, M) • Improvements in operational efficiency & fleet renewal (A, M) • New navigation technology (A) • Route and speed optimization (A, M)	• Sustainability partnerships (A, M) • Waste and recycling improvements, green energy utilization (A, M) • Carbon reduction vs. offsetting (A, M)	• Green fares and green ticket classes (A) • Diverse carbon offset schemes (A) and voluntary carbon offsetting in maritime (M) • SAF purchase options for airline customers (A)
Challenges	• Technological limitations (A, M) • Biofuel availability and high price (A, M) • EU emission restrictions affecting competitiveness of European transport companies (A, M)	• Constantly evolving and escalating EU sustainability rules and regulations (A, M) • Lack of sustainability related standardization (A, M) • External sustainability requirements from stakeholder and investors (A, M)	• Polluter stigma of air travel, flight shaming (A) • Sustainability communication challenges (greenwashing) (A) • Technology preventing substantial competitive advantage benefits from sustainability actions (A, M)
Opportunities	• Improvements in ATM system (A) • Biofuel investments in production and distribution (A, M) • Investments in new technological innovations including common reed utilization in maritime industry (A, M)	• Sustainability as part of company vision (A, M) • Transparent sustainability communication & marketing (A, M) • Sustainable transformation as part of organization´s strategy (A, M)	• Cooperation with regulatory bodies and industries, stakeholders and investors (A, M) • Pursue sustainability leadership (A, M) • Sustainability investments today, customers tomorrow (A, M)

Fig. 1. Airline and Maritime Common Research Findings (Source: Authors' compilation)

When analysing the combined research findings from the airline and maritime industries the authors were able to identify several common challenges and opportunities. Both sectors are increasing their usage of sustainable fuels as initiatives to reduce carbon emissions, while simultaneously striving to improve operational efficiency and renew their fleets. Efforts to optimize routes and speeds are being undertaken in both industries, alongside the acknowledgement of technological limitations as a barrier to sustainability progress. Challenges related to sustainable fuel availability and pricing, as well as the impact of European Union emission restrictions on competitiveness, are shared concerns for both sectors. Additionally, investments in sustainable fuel production and distribution infrastructure are being pursued to overcome these challenges. Both industries are also exploring innovative solutions, such as the utilization of common reed for the maritime sector, to enhance sustainability. Organizational development efforts include the formation of sustainability partnerships, implementation of waste

management improvements, and integration of sustainability into company vision and strategy. Collaboration with regulatory bodies, stakeholders, and investors is seen as essential for advancing sustainability goals and achieving leadership in sustainability practices. Overall, there is a recognition that investments in sustainability today may yield future benefits in terms of customer loyalty and revenue growth for both the airline and maritime sectors. (Pimiä, 2023; Urponen, 2023)

The research findings specific to the airline industry highlight the adoption of new navigation technology aimed at enhancing operational efficiency and safety. Investments in Air Traffic Management (ATM) systems are being made to improve air traffic flow and reduce environmental impact. Furthermore, airlines are implementing diverse carbon offset schemes and introducing green fares and ticket classes to incentivize sustainable travel choices among passengers. However, sustainability communication challenges, such as addressing concerns about greenwashing, remain prominent. Lastly, there is recognition within the industry that technological advancements may hinder the realization of substantial competitive advantages from sustainability actions, prompting a strategic focus on sustainability leadership as a long-term objective. (Pimiä, 2023)

In parallel, findings from the maritime industry case study echoed similar challenges and opportunities. Challenges such as technological constraints and regulatory pressures mirrored those faced by airlines. However, initiatives such as investments in alternative fuels and collaborative efforts with stakeholders presented opportunities for emissions reduction. The maritime industry case study concentrated especially on voluntary carbon offsetting as a possibility for achieving carbon neutrality. The criteria for credible and ethically sound offsetting were established through a review of the literature, emphasizing the importance of additionality (Cames et al., 2016), a solid baseline, a robust calculation method, monitoring and reporting, stability, avoidance of carbon leakage, authenticity, transparency, certifiability, avoidance of double counting, and avoidance of significant harm as fundamental aspects (Finnwatch, 2024; Laine et al., 2021).

When examining the potential of biochar from common reed as a tool for voluntary carbon offsetting the thematic analysis based on the expert interviews revealed that common reed biochar meets entirely the criteria for good compensation. Current challenges related to the high price and harvesting issues could be addressed through the development of relevant legislation and technologies. Unlike domestic forest-related compensation projects, biochar based on common reed would not encounter issues with double counting or additionality. Moreover, there is a biodiversity perspective to consider, as cutting common reed removes nutrients and reduces methane and CO2 emissions from the sea. In addition to benefiting the environment trying to achieve climate neutrality through deliberate offsetting could potentially enhance companies' competitive edge. (Urponen, 2023)

By examining both industries, this research provides practical insights into sustainable transformation efforts and highlights the importance of collaborative action across European transportation sectors to combat climate change.

Conclusions

In conclusion, this study aims to offer a holistic view of sustainability initiatives within European airlines and maritime industries, providing perceptions of the challenges and opportunities shaping the industry's sustainability landscape. Through qualitative interviews and content analysis, the study uncovered key findings that underscore the pressing need for sustainable transformation and collaboration across industries and regulatory bodies.

Table 1. Main Conclusions (Source: Authors´ compilation)

Conclusion	Key Insight
Conclusion 1	The study offers a practical and holistic view on sustainability initiatives within European airlines and maritime industries, highlighting the need for sustainable transformation and collaboration across industries, research institutions, regulatory bodies, and investors, especially in the field of technical development and new innovations.
Conclusion 2	European airline and maritime companies are experiencing persistent challenges in reducing CO2 emissions due to technological limitations, biofuel availability and high price. Sustainability communication is hindered by concerns of green washing.
Conclusion 3	Initiatives in route and speed optimization, waste and recycling improvements, utilizing green energy, including sustainability in company vision and strategy, adopting sustainable business models, fostering organizational development, and leveraging strategic sustainability partnerships, especially in carbon offsetting, were identified. Airline companies' specific initiatives include green fairs, customer SAF purchase options and diverse carbon offsetting schemes, whereas voluntary carbon offsetting is in this study related to maritime companies.
Conclusion 4	EU emission restrictions are strictest in the world, EU regulations are constantly evolving, lack of sustainability standardisation and external pressure from stakeholders and investors affect the competitiveness of European transportation companies.
Conclusion 5	Following principles of credible and ethically correct voluntary carbon offsetting based on internationally defined criteria is essential. Biochar from common reed meets these criteria and benefits biodiversity by reducing sea nutrients, with challenges addressable through future legislative and technological developments.
Conclusion 6	Limitations in qualitative research methods and utilizing information from company sustainability reports and experts were acknowledged. However, reliability was enhanced by interviewing external experts form fields of industry associations, research, and education. Furthermore, the aim of research was to explore current sustainability initiatives of airline and maritime companies and not to evaluate their level of sustainability in essence.

The research highlights the significant strides made by European airlines in embracing sustainability, while also illuminating persistent challenges such as reducing CO2 emissions and enhancing communication strategies. Moreover, findings emphasize the importance of adopting sustainable business models, fostering organizational development, and leveraging strategic partnerships to drive progress in the airline industry. (Pimiä, 2023) Importantly, it is essential to consider a maritime perspective when addressing sustainability challenges, given the shared environmental concerns and regulatory pressures faced by both industries. The study emphasizes the importance of following the principles of credible and ethically correct voluntary carbon offsetting based on internationally defined minimum criteria. Furthermore, it was concluded that biochar from common reed fulfils wholly these minimum criteria and is in addition able to positively affect biodiversity by reducing nutrients from the sea. The challenges related to its use could be tackled with future legislative and technological development. (Urponen, 2023) By aligning efforts between the airline and maritime sectors, synergies can be harnessed to accelerate progress towards common sustainability goals.

It is acknowledged that limitations to this research can be identified. The new insights into the sustainability initiatives related to the aviation and maritime industries were based on a qualitative study, interviewing company representatives, and utilizing the information gained from sustainability reports, which could affect the reliability of the information. To improve the reliability of the aviation part of the research, an external industry expert was interviewed to compare the findings from the companies, which were confirmed. In the maritime industry part, to increase the reliability of the research, by interviewing representatives from fields of research, education, and the public sector, in addition to the company representatives.

In the future, the impact of this research will be gauged by its capacity to catalyse constructive transformations within the airline and maritime sectors. Through encouraging collaboration and knowledge exchange, there is potential to spur innovation, diminish environmental footprints, and elevate sustainability standards across transportation industries in Europe.

In summary, this study underscores the importance of a holistic approach to sustainability, one that considers the unique challenges and opportunities facing both the airline and maritime industries. This study emphasizes the imperative of embracing a sustainability paradigm, tailored to the distinctive landscapes of both the airline and maritime sectors. By fostering unified action towards a sustainable future, the cultivation of the European transportation sector can be anticipated that is not only environmentally conscious but also prepared to meet the needs of generations to come.

References

Anderson, B. (2007). Thematic content analysis. In J. A. Smith (ed.), *Qualitative Psychology: A Practical Guide to Research Methods*, pp. 83-110. Sage Publications.

Boyle, L. (2021). *Carbon offsetting - a new form of colonialism, says indigenous leader.* https://www.independent.co.uk/climate-change/news/cop26-climate-summit-indigenous-offsetting-b1951289.html

Tenny, S., Brannan, J. M., & Brannan, G. D. (2017). *Qualitative study*. StatPearls Publishing.

Brazzola, N., Patt, A. & Wohland, J. (2022). Definitions and implications of climate-neutral aviation. *Nat. Clim. Chang.* 12, 761-767. https://doi.org/10.1038/s41558-022-01404-7

Cames, M., Harthan, R. O., Füssler, J., Lazarus, M., Lee, C. M., Pete, M., & Spalding-Fecher, R. (2016). *How additional is the clean development mechanism?* https://www.oeko.de/publikationen/p-details/howadditional-is-the-clean-development-mechanism

Council of the EU and the European Council. (2024). European Green Deal. https://www.consilium.europa.eu/en/policies/green-deal/

CSR Europe (2024). *The European business network for corporate sustainability and responsibility*. https://www.csreurope.org/

Donaldson, L. (2001). *The contingency theory of organizations*. SAGE Publications, https://doi.org/10.4135/97814522292499

Eriksson, P., & Kovalainen, A. (2016). *Qualitative methods in business research.* SAGE Publications

European Commission. (2024). *Delivering the European Green Deal*. https://commission.europa.eu

Finnwatch (2024). *Finnwatch.* https://finnwatch.org/en/

Hajian, M., & Jangchi, K. (2021). From Brundtland report to sustainable development goals. In C. M. Hussain & J. F. Velasco-Muñoz (eds.), *Sustainable Resource Management*, pp. 1–24. https://doi.org/10.1016/B978-0-12-824342-8.00018-3

International Air Transport Association (IATA) (2024). *International Air Transport Association.* https://www.iata.org/

International Maritime Organization (IMO) (2022). *International Maritime Organization*. Website. https://www.imo.org/en

International Maritime Organization (IMO) (2023). *IMO greenhouse gas reduction strategy revised*. https://www.imo.org/en/MediaCentre/PressBriefings/Pages/27-GHG-reduction-strategy-revised.aspx

Integrity Council for the Voluntary Carbon Market (2024). *Leading the way to high integrity in the voluntary carbon market*. https://icvcm.org

Laine A., Airaksinen J., Yliheljo E., Ahonen H., & Halonen M. (2021). *Regulation of voluntary emissions offsetting. M*inistry of the Environment, Helsinki. http://urn.fi/URN:ISBN:978-952-361-408-6

Luthans, F., & Stewart, G. (1977). A general contingency theory of organizations. *Academy of Management Review*, *2*(2), 181-195.

Mahoney, J., & Goertz, G. (2006). A tale of two cultures: contrasting quantitative and qualitative research. *Political Analysis*, *14*(3), 227-249. https://doi.org/10.1093/pan/mpj017

Nyamdorj, B., Anaka, W., Stoica, A., Sushant, S., Ortega, J., Helm, B., & Moreira, P. (2021). Carbon neutrality, reduction and offset-aviation solutions in the 21st century. *SAE International Journal of Advances and Current Practices in Mobility*, *3*, 1293-1306. https://doi.org/10.4271/2021-01-0039

Pimiä, A. (2023). *Airlines fighting climate change: A comprehensive study on sustainable transformation strategies and initiatives in European airlines.* Master's Thesis, Hame University of Applied Sciences. https://urn.fi/URN:NBN:fi:amk-2023120534447

Porter, M. (1985). *Competitive advantage: creating and sustaining superior performance.* Free Press.

Ritchie, H. (2020). *Climate change and flying: What share of global CO2 emissions come from aviation.* https://ourworldindata.org/co2-emissions-from-aviation

Roemer N., Souza G., Tröster C. & Voigt G. (2023). Offset or reduce: How should firms implement carbon footprint reduction initiatives? *Production and Operation Management, 32*(9), 2940-2955. https://doi.org/10.1111/poms.14017

Romm, J. (2022). *Climate change: What everyone needs to know*. Oxford University Press.

SITRA (2024). *Megatrends. https://www.sitra.fi/julkaisut/megatrendit-2023/*

Paris Agreement. (2015). *The Paris Agreement 2015.* https://unfccc.int/process-and-meetings/the-paris-agreement?gclid=Cj0KCQjwz6ShBhCMARIsAH9A0qVae1uCV6jfgG28e4XStQrW5_HsnR0tuxbGUy7qimVLgEIniTOjEEQaAmKkEALw_wcB

Trouwloon D., Streck C., Chagas T., & Martinus G. (2023). Understanding the use of carbon credits by companies: A review of the defining elements of corporate climate claims. *Global Challenges, 4*(7), 2200158. https://doi.org/10.1002/gch2.202200158

United Nations. (2024). *Sustainable development goals.* https://www.un.org/sustainabledevelopment/

Urponen, A. (2023). *Achieving carbon neutrality in maritime industry – investigating the possibility of complementing reductions by voluntary carbon offsetting with common reed.* https://urn.fi/URN:NBN:fi:amk-2023120333818

Wang, F., Harindintwali, J. D., Yuan, Z., Wang, M., Wang, F., Li, S., Yin, Z., Huang, L., Fu, Y., Li, L., Chang, S. X., Zhang, L., Rinklebe, J., Yuan, Z., Zhu, Q., Xiang, L., Tsang, D. C. W., Xu, L., Jiang, X.,…, & Chen J.M. (2021). Technologies and perspectives for achieving carbon neutrality. *The Innovation, 2,* 100180. https://doi.org/10.1016/j.xinn.2021.100180

Wang, L., Weian, L., & Qi, L. (2020). Stakeholder pressures and corporate environmental strategies: A meta-analysis. *Sustainability, 12*(3), 1172. https://doi.org/10.3390/su12031172

World Bank and United Nations Department of Economic and Social Affairs (2017). *The potential of the blue economy: increasing long-term benefits of the sustainable use of marine resources for small island developing states and coastal least developed countries.* World Bank.

Xu X., Gou X., Zhang W., Zhao Y., & Xu Z. (2023). A bibliometric analysis of carbon neutrality: Research hotspots and future directions. *Heliyon, 9,* e18763. https://doi.org/10.1016/j.heliyon.2023.e18763