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Towards Carbon Neutral Airline Operations by 2045: The Case of Finnair PLC

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Abstract**—***In response to the growing concerns over their impact on the environment and climate change, a number of the world's airlines have announced plans to become fully "carbon neutral". Using an in-depth instrumental case study research approach, this study examines the strategies defined and implemented by Finnair to meet its goal of becoming a "carbon neutral" airline by 2045. The qualitative data, covering the period 2010 to 2019, was analyzed using document analysis. The study found that the operation of a modern, fuel-efficient aircraft fleet underpins Finnair's goal of becoming a carbon neutral airline. Other measures implemented by Finnair include a carbon offset program for its passengers and corporate customers, more sustainable waste management practices, the use of aviation biofuels where possible to power their aircraft operations, the use of biodiesel for ground service equipment (GSE), the electrification of ground vehicles, and measures to reduce aircraft weight. Finnair's annual Scope 1 carbon dioxide (CO_2) emissions from jet fuel usage have increased from 2010 to 2019 due to fleet and route network expansions. The airline's Scope 1 carbon dioxide (CO_2) emissions from ground vehicles fuel usage declined over the study period. The annual Scope 2 carbon dioxide (CO_2) emissions for electricity and heating oscillated over the study period reflecting changes in usage patterns, particularly for heating during the winter periods. Finnair's annual Scope 3 carbon dioxide (CO_2) emissions exhibited an upward trend due to the carbon dioxide (CO_2) emissions associated with the manufacture of the airline's new Airbus A350-900XWB aircraft, the greenhouse gas emissions (GHGs) associated with the production and transportation of jet fuel, emissions from leased vehicles, and emissions from cargo flights that were operated on behalf of Finnair Cargo.*

Keywords**—*****Aircraft, Airline, Airline carbon footprint, Carbon neutral airline operations, Carbon dioxide (CO_2) emissions, Case study, Finnair.***

I. INTRODUCTION

Many airlines around the world have recognized the importance of environmental protection (Niu et al., 2016), and considering this many airlines have taken strong environmental positions (Roza, 2009). Indeed, airlines have become increasingly committed to becoming more "green," or environmentally friendly (Hagmann et al., 2015; Jalalian et al., 2019; Migdadi, 2018, 2020c; Zhou & Zhang, 2020). A "green airline" is a relatively new concept – and represents initiatives by the airline to support sustainable social and economic development without impacting the local and global environment (Sarkar, 2012). The objective of a "green airline" is to provide the green society with a transport system that reduces its carbon footprint, uses renewable energy, and produces less carbon dioxide (CO_2) emissions as well as other harmful pollutants (Abdullah et al., 2016). The concept of "greening" aviation firms, such as, airlines, can be best linked to their reduction of emissions into the atmosphere, to the point where they achieve near carbon neutrality (Sarkar, 2012). Carbon neutrality means every ton of anthropogenic carbon dioxide (CO_2) emitted is compensated with an equivalent amount of carbon dioxide (CO_2) removed (Levin et al., 2015). Furthermore, the adoption of a green operations strategy by an airline is a combination of green operational actions that are undertaken to acknowledge green indicators (Migdadi, 2020b).

The world's peak global airline industry body – the International Air Transport Association (IATA) – have recognized the requirement to address the global challenge of climate change and in response has adopted a set of ambitious targets to mitigate carbon dioxide (CO_2) emissions arising from air transport operations. The association has targeted an average improvement in aircraft fuel efficiency of 1.5% per year from 2009 to 2020, a cap on net aviation carbon dioxide (CO_2) emissions from 2020, and a reduction in net aviation carbon dioxide (CO_2) emissions of 50% by 2050, relative to 2005 levels (International Air Transport Association, 2018). Importantly, the direct greenhouse gas emissions that are produced from aircraft operations and the use of ground service equipment (GSE) contribute to the world's total greenhouse gas emissions (Migdadi, 2020a). Aviation emissions are the source of around 2 to 3 per cent of global greenhouse gas emissions (Birchfield, 2015).

Considering the IATA policy to reduce carbon dioxide (CO_2) emissions, member airlines have introduced plans and strategies that are aimed to achieve this policy objective. Furthermore, several of the world's major airlines have announced plans to become fully "carbon neutral" (Becken, 2020; Cui & Li, 2021; Cui et al., 2020). The key aim of this study is to gain an insight into how airlines can achieve their goal of carbon neutral operations. To achieve this aim, Finland-based Finnair PLC. was selected as the case airline for this study. Finnair was the first airline in the world to announce their intention to cut their net carbon emissions by 50% from 2019 levels by the end of 2025, and for the airline to be fully "carbon neutral" by 2045 (Bailey, 2020; Finnair, 2021b; Taylor, 2020). The key objective of this study was to examine the strategies that the airline has defined and implemented to achieve its carbon neutral operations goal. A second objective was to examine Finnair's annual carbon footprint and to identify the impact that the carbon neutrality strategy has had on its carbon footprint. According to Wiedemann and Minx (2007, p. 5), "the carbon footprint is a measure of the exclusive total amount of carbon dioxide emissions that is directly and indirectly caused by an activity or is accumulated over the life stages of a product". An additional objective is to examine the role that the airline's aircraft fleet will pay as part of its carbon neutrality strategy. The study covers the period 2010 to 2019.

The remainder of the paper is organized as follows: the literature review is presented in Section 2, and this sets the context of the case study. The research method that underpinned the study is outlined in Section 3. The Finnair case study is presented in Section 4. Section 5 presents the findings of the study.

II. BACKGROUND

2.1 Aircraft and Ground-Based Equipment and Vehicle Emissions

Aviation emissions are a significant contributor to global climate change (Markham et al., 2018). By consuming fuel, aircraft produce emissions of carbon dioxide (CO_2), nitrogen oxides (NO_X), particles (principally soot) of sulphur oxides (SO_X), carbon monoxide (CO), as well as various hydrocarbons. First, and generating the largest percentage share, are the emissions of carbon dioxide (CO_2) which are produced in direct proportion to the volume of jet fuel used to operate flights over any distance (Sales, 2013, 2016). Water vapor is formed from the burning of jet fuels. At altitude, condensation trails from the aircraft. These comprise frozen ice crystals which deflect a small amount of sunlight away from the earth's surface and reflect more infrared radiation back toward earth. This produces an overall warming effect on the earth's atmosphere (Sales, 2013). After water vapor, carbon dioxide (CO_2) is regarded as the second most important of all the greenhouse gases (Drewer et al., 2018; Ngo & Natowitz, 2016).

Aircraft emissions present potential risks relating to public health (Barrett et al., 2010; Levy et al., 2012). Furthermore, aircraft often travel considerable distances at a variety of altitudes, generating emissions that may potentially have an impact on air quality in not only local, but also regional and global environments (International Civil Aviation Organization, 2011).

Growing environmental concerns in recent times have also drawn the attention of the airline industry towards the requirement for judicious use of aviation fuel. As a result, both economic and environmental sustainability concerns have resulted in significant progress in aviation fuel efficiency improvements in recent times (Singh et al., 2018). The airlines and the aircraft manufacturers have invested in new technologies and strategies to reduce fuel consumption and the related emissions (Zou et al., 2016). Aircraft fuel burn is highly correlated with emissions whilst also directly contributing to transport externalities (Park & O'Kelly, 2014).

Air pollution at an airport is also produced from the ground service equipment (GSE) used during aircraft turnaround and ground handling operations (Sameh & Scavussi dos Santos, 2018; Testa et al., 2014). Ground service equipment (GSE) is any piece of mobile equipment, whether powered or self-propelled, that is purpose designed, built, and used for the ground handling, servicing, or field maintenance of civil transport aircraft on the ramp or apron area of an airport (International Organization for Standardization, 2014). Accordingly, the ground service equipment (GSE) carbon dioxide (CO_2) emissions can also be significant at airports (International Airport Review, 2010).

2.2 Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA)

In October 2016, the Member States of the International Civil Aviation Organization (ICAO) reached a decision to adopt a world-wide market-based measure for aviation emissions (Attanasio, 2018; Scheelhaase et al., 2018). In 2021, an increasing share of the carbon emission growth in international air transport will be subject to offsetting under the ICAO "Carbon Offsetting and Reduction Scheme for International Aviation" (CORSIA) program (Maertens et al., 2019). CORSIA is a worldwide based market-based measure that has been designed to offset international aviation carbon dioxide (CO_2) emissions to stabilize the levels of such emissions from 2020 onwards. The offsetting of carbon dioxide (CO_2) emissions in the air transport industry will be achieved through the acquisition and cancelation of emissions units from the global carbon market by aircraft operators (International Civil Aviation Organization, 2021). The CORSIA program will be rolled out in three phases with the pilot phase operating from 2021-2023. The first phase will be from 2024 to 2026. Both the pilot and first phases are voluntary. The second phase of the program is targeted from 2027 to 2035 (Javed et al., 2019). Following the pilot and first phase, a second mandatory scheme will enter in effect for all ICAO Member States, except for some least developed countries (Scott & Trimarchi, 2020). The COVID-19 pandemic resulted in a very significant decline in the global aviation industry traffic (Czerny et al., 2021; Li, 2021; Liu et al., 2020) and, as a result, the International Civil Aviation Organization (ICAO) adjusted its CORSIA program by removing 2020 emissions from the baseline, which are now based on 2019 emission levels (Zhang et al., 2021). The voluntary pilot period for ICAO's CORSIA program became effective as of 2021 and will become mandatory for all airlines from 2027 onwards (Singapore Airlines, 2021).

2.3 Offsetting of Carbon Emissions by Airline Passengers

Carbon offsetting has become an integral element of the airline industry strategy to reduce its carbon emissions (Becken & Mackey, 2017). Consequently, airlines are now offering carbon offset schemes for their passengers so that they can reduce their carbon footprint (Chen, 2013; Ritchie et al., 2020; Zhang et al., 2019). Voluntary carbon offsetting by airline passengers is a useful measure that could help reduce environmental damage caused by air travel (Babakhani et al., 2017). In the global airline industry, carbon offsetting is a means for individuals or firms, in this case airline passengers and corporate customers, to "neutralize" their proportion of an aircraft's carbon emissions on a particular journey through an investment in carbon reduction projects (International Air Transport Association, 2021b). The principle of carbon offsetting is that the emissions for each flight are allocated amongst the passengers. Each passenger can therefore pay to offset the emissions caused by their portion of the flight's emissions. Passengers can offset their emissions through an investment in carbon reduction projects that generate carbon credits (International Air Transport Association, 2016).

Passengers participating in carbon offset programs can purchase carbon credits generated by certified renewable energy and energy efficiency projects in developing countries. These projects have been verified that they will reduce greenhouse gas emissions. A carbon credit is a permit that represents one tonne of carbon dioxide (CO_2) that has either been removed from the atmosphere or alternatively saved from being emitted. Once used these carbon credits are subsequently "cancelled" on an official register to ensure that they cannot be sold or used again (International Air Transport Association, 2016).

Carbon credits establish a market for the reduction in greenhouse emissions by providing a monetary value to the cost of polluting the air (International Air Transport Association, 2016). There are two major types of carbon credits: certified emission reductions (CERs) and voluntary emission reductions (VERs) (Bayon et al., 2009; Harris, 2019).

2.4 The Greenhouse Gas Protocol

The Greenhouse Gas Protocol has established a comprehensive global standardized framework to measure and manage greenhouse gas (GHG) emissions from both the private and public sectors, through value chains, and mitigation actions (Greenhouse Gas Protocol, 2021). The Greenhouse Gas Protocol categorizes greenhouse gases into both direct and indirect emissions and further categorizes them into Scope 1, Scope 2, and Scope 3 emissions (Jones, 2009). Scope 1, direct emissions, includes those emissions from sources that are owned or controlled by the firm (Girella, 2018; Vásquez et al., 2015). Scope 2, indirect emissions, come from the purchase of electricity, heat, steam or cooling. Scope 3 emissions are all the other indirect emissions that arise from the consequences of the various activities undertaken by a firm but occur from sources that are not owned nor controlled by that firm (Mazhar et al., 2019).

Although there are variations in air quality regulations by country (Budd, 2017), airlines are now increasingly recording and reporting emissions in terms of Scope 1, Scope 2, or Scope 3 emissions. Finnair, the case airline in the present study, is one such airline that follows this practice.

2.5 Reduction in Aircraft Weight

In recent times, airlines from around the world have implemented a range of measures that have been designed to lower the weight of their aircraft, and thus, reduce fuel burn and the associated harmful emissions. The weight saving initiatives include the correct stowage of items to avoid unnecessarily ordering catering supplies and other in-flight service equipment, the removal of rubbish, and the reduction in on-board company materials. In addition, airlines have implemented potable water strategies whereby they carefully optimize the water uplift on flights to satisfy passenger requirements whilst at the same time achieving fuel and emissions savings from the lower the aircraft weight (Baxter, 2016).

2.6 Sustainable Airline Waste Management

Airlines produce substantial volumes of waste which typically includes food and drink containers, newspapers and magazines, food waste (from offices, lounges/cafeterias, and in-flight services), light bulbs, printer toner, paper, documents, and computer print outs (Baxter et al., 2018). Deplaned aircraft waste is waste that originates on an airline's flights. Cabin waste is comprised of two principal streams: cleaning waste and catering (galley) waste (International Air Transport Association, 2021a). The volume and characteristics of waste generated on an aircraft are normally dependent upon the length of the flight being operated (Chandrappa & Das, 2012).

Airlines often dispose of their wastes through recycling, incineration, composting, or by landfill (Baxter et al., 2021). When recycling waste, the waste fraction is utilized again to produce consumer goods or other products. Recycling of wastes may also include the conversion of waste into energy through thermal treatment (processing) (Fulekar, 2010; Skrifvars & Åkesson, 2016). Energy recovery reduces the volume of waste that is disposed by landfill and produces useable energy, in terms of heat, electricity or fuel, through a variety of processes. These processes include combustion, gasification, pyrolysis, and anaerobic digestion (Rahman et al., 2017). With incineration the waste fraction is incinerated. During waste incineration, there are substantial emissions of carbon dioxide (CO_2) (Reinhardt et al., 2008; Tarczay et al., 2011). There may also be smaller amounts of methane and nitrous oxide emissions (Tarczay et al., 2011). Composting waste is a process whereby the organic portion of solid waste is converted into a humus-like product. The final product, which is inert in nature, can be utilized as a soil conditioner or for landfill cover (Harper, 2004, p. 3). There are several advantages associated with the composting of rubbish: lower operational costs, lessened environmental pollution, as well as the beneficial use of the end products (Taiwo, 2011). Wastes disposed by landfill undergo biological, chemical, and physical transformations that result in changes in solid, liquid (leachate), and gas phases (Pawlowska, 2014). Disposal in landfill sites is regarded as the least desirable option (Barlow & Morgan, 2013; Manahan, 2011; Pitt and Smith, 2003).

2.7 The use of Sustainable Aviation Biofuels

In recent times, there has been a growing trend by airlines to use aviation biofuel as an environmental sustainability measure (Baxter et al., 2020; Dodd & Yengin, 2021; Neuling & Kaltschmitt, 2018). Concerns associated with climate change and energy supply have been driving the production of more sustainable aviation fuels (Brooks et al., 2016). Accordingly, alternative jet fuel (AJF) technologies have gained considerable interest as a way for the industry to achieve large, near-term emissions reductions (Staples et al., 2014). Sustainable jet fuels represent an especially important element in the airline industry's strategy to reduce their carbon emissions (Gegg et al., 2014; Schäfer, 2016). Depending upon the raw material used in its production, biofuels can reduce carbon dioxide (CO_2) emissions by 60-80% (Bioenergy International, 2019; Tavares Kennedy, 2019).

Aviation biofuels are therefore becoming an important substitute for fossil fuel in the airline industry as they offer several advantages including sustainability, they are environmentally friendly, and they offer good adaptability (Su et al., 2015). In addition, the replacement of fossil fuels by jet-biofuels is one of the primary strategies to decrease carbon dioxide (CO_2) emissions by 50% by 2050 (Bauen & Nattrass, 2018; Dodd et al., 2018). Thus, the aviation industry has recognized the importance of sustainable biofuels as being the key long-term technology for decarbonizing aviation (Fregnani & Andrade, 2017).

III. RESEARCH METHODOLOGY

3.1 Research Method

This study used an instrumental case study research approach. An instrumental case study is a research approach that facilitates the understanding of a phenomenon (Grandy, 2010). An instrumental case study is also the study of a specific case, for example, a firm, that provides insights into a specific issue, redraws generalizations, or builds theory (Stake, 1995, 2005). The goal of the case study approach is to expand and build theories rather than perform statistical analysis to test a study's specific hypothesis (Rahim & Baksh, 2003). The present study was designed around the established theory of sustainable (green) aviation management (Abdullah et al., 2016; Agarwal, 2009, 2012; Budd et al., 2020; Dryer, 2017; Palmer, 2020).

3.2 Data Collection

Data for the study was obtained from a range of documents: Finnair's annual sustainability reports, Finnair's annual reports, media releases, and the airline's websites. These documents provided the sources of the study's case evidence. A comprehensive search of the leading air transport journals and magazines was also conducted in the study. A search of the SCOPUS and Google Scholar databases was also conducted.

The key words used in the database searches included "Finnair environmental responsibility policy", "Finnair passenger carbon offset program", "Finnair's membership of CORSIA", "Finnair aircraft fleet fuel efficiency", "Finnair's aircraft fleet modernization", "Finnair annual Scope 1, 2 and 3 carbon dioxide emissions (CO_2)", "Finnair sustainable waste management" and "Finnair carbon neutrality measures", "Finnair's use of sustainable aviation biofuels".

This study used secondary data. The three principles of data collection as recommended by Yin (2018) were followed: the use of multiple sources of case evidence, creation of a database on the subject and the establishment of a chain of evidence.

3.3 Data Analysis

Document analysis was used to examine the data collected for the case study. Document analysis is extensively used in case studies (Grant, 2019; Monios, 2016) and focuses on the information and data from formal documents and company records collected for the case study (Baxter, 2021; Ramon Gil-Garcia, 2012). The effective use of documents gathered for a study is dependent on them being appraised in terms of four key criteria: authenticity, credibility, representativeness and meaning (Scott, 2004, 2014).

Prior to commencing the formal analysis of the gathered documents, the soundness and authorship was assessed (Scott, 2004). According to Scott and Marshall (2009, p.188), "soundness refers to whether the document is complete and whether it is an original and sound copy". Authorship of documents relates to such issues as collective or institutional authorship. In this study the source of the case study documents was Finnair. When conducting document analysis in a study, it is necessary to interpret the understanding and the context within which the document was produced. This enables the researcher(s) to interpret the meaning of the document. The evidence found in the documents collected and used in the study were all clear and comprehensible (Baxter, 2021; van Schoor, 2017).

The document analysis was conducted in six distinct stages. The first stage involved planning the types and required documentation and ascertaining their availability. The second stage in the document analysis process involved gathering the documents and developing and implementing a scheme for the document management. Following the conclusion of Stage 2, the documents were reviewed to assess their authenticity, credibility and to identify any potential bias. In the subsequent stage, the content of the collected documents was interrogated, and the key themes and issues were identified and were incorporated into the case study. Stage 5 involved reflection and refinement to identify any difficulties associated with the documents, reviewing sources, as well as exploring the documents content. The analysis of the data was completed in Stage 6 of the document analysis process (O'Leary, 2004).

All the gathered documents were downloaded and stored in a case study database (Yin, 2018). The documents gathered for the study were all in English. Each document was carefully read, and key themes were coded and recorded. Documents were collected from multiple sources. This approach helped verify the themes that were detected in the documents that were used in the study (Baxter, 2021; Kitamura, 2019).

IV. RESULTS

4.1 A Brief Overview of Finnair

Finnair was established by private interests as Aero O/Y on 1 November 1923. The airline commenced operations on 20 March 1924 with a service from Reval in Estonia, and shortly thereafter a Helsinki-Stockholm service via Turku was started in conjunction with ABA of Sweden (Chant, 1997; Green & Swanborough, 1975). The airline operated exclusively with seaplanes prior to the opening of Finland's first airports in 1936 (Taylor & Young, 1975). In the immediate post World War II years, the airline operated a fleet of ex-military Douglas DC3 aircraft. Services were expanded to other European countries. The Finnish Government commenced purchasing stock in the airline in the 1950s and 1960s, and today the airline is substantially government owned (Brimson, 1985).

In 1986, the airline changed its name to Finnair. At this point of time the company was seeking to establish a more distinctive, nationalistic image (Brimson, 1985). Finnair joined the major global airline alliance **one**world in September 1999 (Hayward, 2019).

Today, Finnair is a full-service network carrier (FSNC) that specializes in both passenger and air cargo transportation. According to Ehmer et al. (2008, p. 5), a "full-service network carrier is an airline that focuses on providing a wide range of pre-flight and onboard services, including different service classes, and connecting flights". Finnair also offers package tours under its Aurinkomatkat-Suntours (later Aurinkomatkat) and Finnair Holidays brands. The cornerstone of Finnair's sustainable, profitable growth strategy is the airline's competitive geographical advantage, which enables the quickest connections in the growing market of air traffic between Asia and Europe (Finnair, 2019a, 2020a). At the time of the present study, the Finnair aircraft fleet consisted of 80 aircraft, which included 16 state-of-the art Airbus A350-900XWB aircraft (Finnair, 2021c).

4.2 Finnair Environmental Responsibility Policy

Finnair's environmental management is predicated upon the principle of continuous and systematic improvement. The company has identified the key environmental aspects arising from its operations, their impacts, risks, and opportunities involved, and has a range of targets related to them. Finnair aims to be an engaged leader in the field of environmental responsibility. As noted earlier, the airline is committed to the common goal of the global airline industry to achieve carbon neutral growth from 2020 and reduce the emissions from its flight operations by half by 2050 from the 2005 level. Finnair aims to be a pioneer in evaluating, reducing, and reporting environmental impacts. The company is also fully committed to comply with existing environmental legislation; however, its environmental work aims at exceeding statutory requirements (Finnair, 2020b).

Finnair is an active participant in civil aviation environmental committees as well as in industry workgroups in Finland and the Nordic countries. The airline actively promotes the necessity for the reduction of the aviation sector's environmental load. The airline maintains an open dialogue with different stakeholders and aims to continuously develop its operations according to the latest available information. Where possible, Finnair implements new technologies as part of its environmental responsibility. Finnair regularly reports on the company's environmental impacts through its annual reports and as a part of the Carbon Disclosure Project (CDP) (Finnair, 2020b).

In 2016, Finnair became a part of the International Civil Aviation Organization's "Carbon Offsetting and Reduction Scheme for International Aviation" (CORSIA) (Finnair, 2018b). All the company's environmental goals, targets, impacts, and promotion are managed and continuously developed through Finnair's "Environmental Management System" (EMS). The EMS system complies with the International Air Transport Association (IATA), the peak global airline body, "Environmental Assessment Program (IEnvA) Stage 2" as well as the ISO 14001:2015 Environmental Management System standard. IEnvA is an environmental management program that was developed by IATA specifically for airlines. Finnair's use of this program enables them to make use of the best industry practices in the industry (Finnair, 2020b).

Finnair considers all environmental aspects and impacts in all its flight and ground operations. In addition to the energy solutions that help reduce the company's environmental load, Finnair's environmental strategy also includes the implementation of circular economy principals as well as the preservation and promotion of natural diversity. The latter is known as biodiversity thinking (Finnair, 2020b).

During the period 2020 to 2025, Finnair will be investing €60 million in sustainability related measures (Air Transport Action Group, 2020; Centre for Aviation, 2020). This investment is in addition to the mandatory European Union Emissions Trading Scheme (ETS) and other environment related payments (Centre for Aviation, 2020). Effective from 1st January 2012, the European Union decided to include the aviation industry in the European Union Emission Trading Scheme (EU-ETS). This decision was in accordance with the Directive 101/2008/EC (Li & Tang, 2017; Meleo et al., 2016; Nava et al., 2018).

4.3 Finnair Annual Carbon Footprint

Virtually all of Finnair Group's greenhouse gas (GHG) emissions arise from the airline's flight operations. In 2015, as part of the implementation of the company's new IEnvA Environmental Management System (EMS), Finnair updated its carbon dioxide (CO_2) reduction target. Finnair committed to reducing its carbon dioxide (CO_2) emissions by 20% per one hundred tonne kilometres flown from the 2009 level by 2017 (Finnair, 2015). Finnair's long-term efficiency target has subsequently been to reduce carbon emissions by 17% relative to the revenue tonne kilometres (RTKs) from 2013 levels by the end of 2020. At the end of the 2019, the airline's emission efficiency had decreased by 8.8% and Finnair predicts it can reach 12–13% reduction by 2020 leaving the performance 4–5% short from the original emissions reductions target. The principal reason for this is that Finnair has been growing faster than the market in general and the original aircraft fleet renewal schedule from some time ago has changed from the previously estimated aircraft fleet requirements (Finnair, 2020b).

Figure 1 presents Finnair's annual Scope 1 direct carbon dioxide (CO_2) emissions from aircraft jet fuel usage over the period 2010 to 2019. As can be observed in Figure 1, Finnair's annual Scope 1 direct carbon dioxide (CO_2) emissions from jet fuel usage have predominantly increased over the study period reflecting the growth in the aircraft fleet and the airline's route network expansion. The largest increases occurred in 2011 (13.55%), 2015 (13.52%), and 2018 (11.89%), respectively (Figure 1). Figure 1 also shows that there were several years where the annual Scope 1 direct carbon dioxide (CO_2) emissions from jet fuel usage declined, with the largest decline occurring in -5.51%. Small decreases were also recorded in 2012 (-1.9%) and 2014 (-0.90%) (Figure 1).

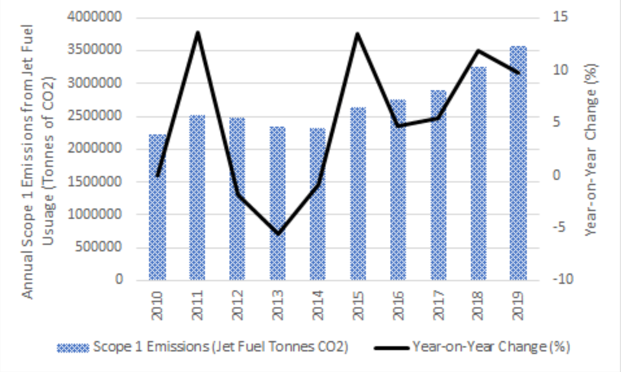

Fig.1: Finnair's total annual Scope 1 carbon dioxide (CO_2) emissions from jet fuel: 2010-2019. Data derived from Finnair (2013, 2015, 2019b, 2020b).

Figure 2 presents Finnair's annual Scope 1 carbon dioxide (CO_2) direct emissions from ground vehicle fuel usage over the period 2015 to 2019. As can be observed in Figure 2, there was a decline in the carbon dioxide (CO_2) levels from 2010 to 2014, with the largest annual fall in carbon dioxide (CO_2) emissions occurring in 2013 (a reduction of 83.65%). In 2015 and 2016, the annual carbon dioxide (CO_2) emission levels remained relatively constant. There was, however, an increase of 229% in carbon dioxide (CO_2) emissions in 2017, reflecting higher ground vehicle and equipment usage. During 2019, the level of carbon dioxide (CO_2) emissions once again declined (11.52%), reflecting the use of more environmentally friendly ground vehicles and equipment (Figure 2). During the study period, Finnair was transitioning from diesel powered vehicles and ground service equipment (GSE) to electric powered vehicles, which will result in lower levels of carbon dioxide (CO_2) emissions. The electrification of vehicles and ground service equipment used at airports results in lower carbon dioxide (CO_2) emissions (Gellings, 2011).

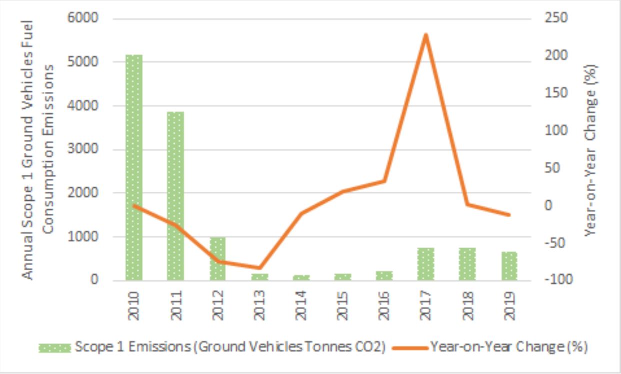

Fig.2: Finnair's total annual Scope 1 carbon dioxide (CO_2) emissions from fuel for ground vehicles and equipment: 2010-2019. Data derived from Finnair (2013, 2015, 2019b, 2020b).

In Finland, the energy consumption of buildings accounts for over a third of total greenhouse gas (GHG) emissions. Finnair uses various measures, for example, repairs, alterations, preventive maintenance together with user training, to ensure the energy efficiency of its business premises and to mitigate the greenhouse gas emissions arising from the energy consumption of its buildings (Finnair, 2020b). Figure 3 presents Finnair's annual Scope 2 carbon dioxide (CO_2) direct emissions from electricity usage from 2010 to 2019. As can be observed in Figure 3, there was a very large spike in Finnair's annual Scope 2 carbon dioxide (CO_2) emissions from electricity in 2011, which increased by 434.5% on 2010 levels. There was a smaller increase recorded in 2012 of 16.54% (Figure 3). Figure 3 also shows that from 2013 to 2015, Finnair's annual Scope 2 carbon dioxide (CO_2) direct emissions from electricity usage declined each year reflecting more favorable electricity usage. However, over the period 2016 to 2018, the annual Scope 2 direct carbon dioxide (CO_2) emissions from electricity increased each year which could be attributed to greater electricity requirements. However, in 2019, Finnair's annual Scope 2 direct carbon dioxide (CO_2) emissions from electricity usage decreased by 26.93%, the second largest decrease recorded in the study period. This could be contributed to the lower electricity requirement by the airline in 2019 (Figure 3).

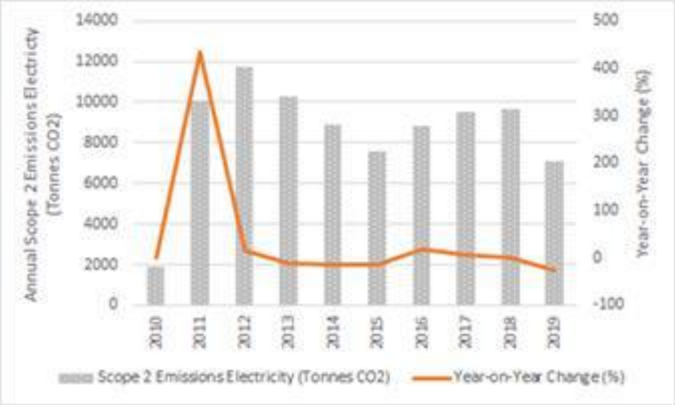

Fig.3: Finnair's total annual Scope 2 carbon dioxide (CO_2) emissions from electricity: 2010-2019. Data derived from Finnair (2013, 2015, 2019b, 2020b).

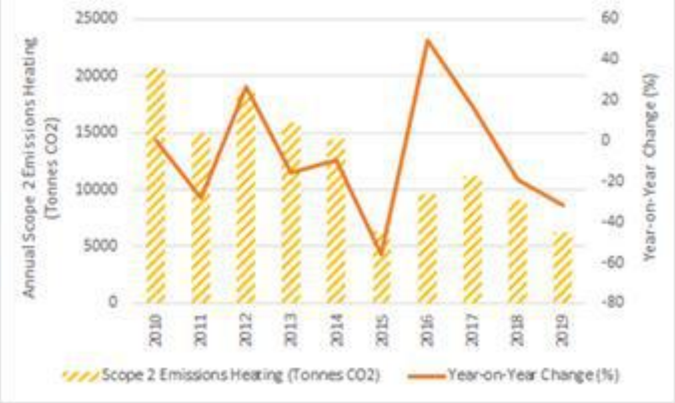

Fig.4: Finnair's total annual Scope 2 carbon dioxide (CO_2) emissions from heating: 2010-2019. Data derived from Finnair (2013, 2015, 2019b, 2020b).

Figure 4 presents Finnair's annual Scope 2 direct carbon dioxide (CO_2) emissions from heating facilities usage over the period 2010 to 2019. Finland's climate is characterized by long, cold winters (Climates to Travel, 2021). As can be seen in Figure 4, the largest level of emissions from heating occurred in 2010. Finland's 2009–2010 winter was the coldest experienced in the country since the 1986–1987 winter (Finnish Meteorological Institute, 2011), and thus, there was a greater requirement for the heating of facilities in 2010. The second highest level of carbon dioxide (CO_2) emissions from heating facilities occurred in 2012 with a 26.59% increase on the 2011 levels. During 2012, there was a greater requirement for Finnair to heat their facilities due to the cold weather experienced in Finland (Figure 4). The total annual carbon dioxide (CO_2) emissions from heating declined in 2013, 2014 and 2015, respectively. In 2015, carbon dioxide (CO_2) emissions from heating decreased by 55.53% on 2014 levels (Figure 4), which represented the largest single decline during the study period. However, the carbon dioxide (CO_2) emissions from heating rose again in 2016 and 2017 reflecting greater heating requirements due to weather conditions before declining again in 2018 and 2019 (Figure 4). The lowest level of Scope 2 direct emissions from heating occurred in 2019 (6,205 tonnes) (Figure 4).

Prior to examining Finnair's annual Scope 3 carbon dioxide (CO_2) emissions, it is important to note that Finnair (2020b) have observed that the greenhouse gas (GHG) emissions arising from the production and transport of jet fuel constitute a significant proportion of the airline's indirect greenhouse gas (GHG) emissions balance. In addition, any business travel made on another airline's services is also reported under the airline's Scope 3 indirect carbon dioxide (CO_2) emissions.

Figure 5 presents Finnair's annual Scope 3 indirect carbon dioxide (CO_2) emissions from 2015 to 2019. As can be observed in Figure 5, the annual Scope 3 indirect carbon dioxide (CO_2) emissions have increased on year-on-year basis. This is illustrated by the year-on-year percentage change line being all positive. During this period, the largest increase occurred in 2018 when the company's total annual Scope 3 emissions increased by 11.97%. However, in 2019 the total annual Scope 3 carbon dioxide (CO_2) emissions increased at a lower rate (9.77%) than that recorded in 2018 (Figure 5).

There have been a range of factors that influenced the annual Scope 3 emissions over the study period. The indirect greenhouse gas emissions arising from the manufacture of four Airbus A350-900XWB aircraft amounted to an estimated 8,484 tonnes of carbon dioxide (CO_2) that were included in Finnair's emissions balance in 2016. At the end of 2016, Finnair had a total fleet of 708 leased cars. Their combined emissions amounted to 1,663 tonnes of carbon dioxide (CO_2), which was 4.5% higher than in 2015. Finnair's indirect carbon dioxide (CO_2) balance also included the air cargo capacity that was purchased from other airlines by Finnair Cargo, Finnair's air cargo division. In 2016, this additional air cargo capacity produced around 8,943 tonnes of carbon dioxide (CO_2) emissions. The amount of these emissions includes cargo flights that were operated solely for Finnair Cargo (Finnair, 2017). The greenhouse gas emissions associated with the production and transportation of jet fuel amounted to an estimated 632,974 tonnes of carbon dioxide (CO_2) in 2017. The indirect greenhouse gas emissions arising from the manufacture of seven Airbus A321 and four Airbus A350-900XWB aircraft amounted to an estimated 13,077 tonnes of carbon dioxide (CO_2) in 2017 (Finnair, 2018a). The greenhouse gas (GHG) emissions associated with the production and transport of jet fuel amounted to around

701,701 tonnes of carbon dioxide (CO_2) in 2018 (Finnair, 2019b) (Figure 5).

Finnair Cargo purchases transport services from trucking firms, and the statistical practices of these firms at the time of the present study did not allow the actual emissions to be calculated. Finnair Cargo's main trucking partners use vehicles classified as EURO 4 as a minimum (Finnair, 2020b).

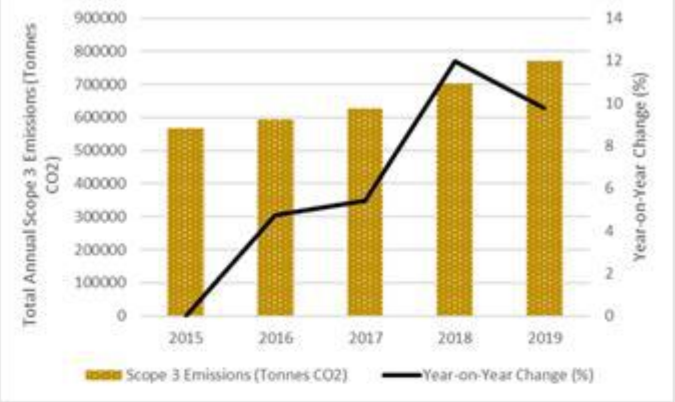

Fig.5: Finnair's total annual Scope 3 carbon dioxide (CO_2) emissions: 2010-2019. Note: data prior to 2015 is not available. Data derived from Finnair (2015, 2019b, 2020b).

Figure 6 shows Finnair's annual carbon dioxide (CO_2) emissions per revenue passenger kilometre (RPK) performed (RPK) from 2010-2019. Revenue passenger kilometres (RPKs) are a measure of airline output and can be obtained by multiplying the number of passengers by the distance (kilometres) flown (Dileep & Kurien, 2022). During the study period, the carbon dioxide (CO_2) emissions per revenue passenger kilometre performed (RPKs) largely exhibited a downward trend, which is illustrated by the year-on-year percentage change line being more negative than positive. As can be observed in Figure 6, the annual carbon dioxide (CO_2) emissions per revenue passenger kilometre performed (RPK) declined over the period 2011 to 2014. In 2015, the annual carbon dioxide (CO_2) emissions per revenue passenger kilometre performed (RPK) increased by 32.97%, the largest single annual increase recorded in the study period. Having peaked in 2015, the annual carbon dioxide (CO_2) emissions per revenue passenger kilometre performed (RPK) exhibited a downward trend from 2016 to 2019 (Figure 6). Figure 6 also shows that Finnair's carbon dioxide (CO_2) emissions per revenue passenger kilometre performed (RPK) have declined from a high of 125.91 grams in 2015 to 113.01 grams in 2019. This favorable trend could be attributed to the operation of the modern, state-of-the art aircraft, for example, the Airbus A350-900XWB, which offer lower carbon dioxide (CO_2) emissions when compared with previous generation aircraft. In addition, Finnair's annual RPKs have grown strongly reflecting greater passenger patronage. Also, during the study period, Finnair expanded its route network which provided the airline with the opportunity to grow its annual revenue passenger kilometres (RPKs) performed.

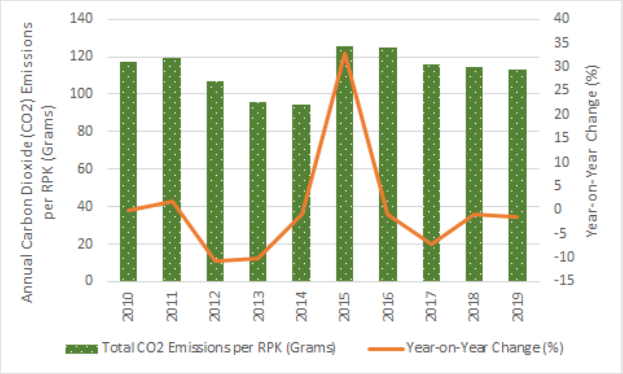

Fig.6: Finnair's total annual carbon dioxide (CO_2) emissions per revenue passenger kilometre (RPK): 2010-2019. Data derived from Finnair (2013, 2015, 2019a, 2019b, 2020b).

Figure 7 presents Finnair's annual carbon dioxide (CO2) emissions per available seat kilometre for the period 2010-2019. An available seat kilometre (ASK) is a measure of an airline's flight's passenger carrying capacity. ASKs are calculated by multiplying the number of seats on an aircraft by the distance that the aircraft has flown (Heshmati & Kim, 2016; Vasigh et al., 2015). Figure 7 shows that Finnair's annual carbon dioxide (CO_2) emissions per available seat kilometre declined during the period 2010 to 2014. In 2015, there was, however, a pronounced spike of 32.97% (Figure 7). This was the only increase recorded during the study period. Since 2015, there has been a consistent downward annual decrease in Finnair's annual carbon dioxide (CO_2) emissions per available seat kilometre from the high of 125.91 grams in 2015 to 113.01 grams in 2019 (Figure 7). Despite the growth in passenger capacity (ASKs) arising from Finnair's route network expansion, the operation of a modern, state-of-the art aircraft fleet over the enlarged route network has contributed to this favorable trend in lower carbon dioxide (CO_2) emissions per ASK since 2015.

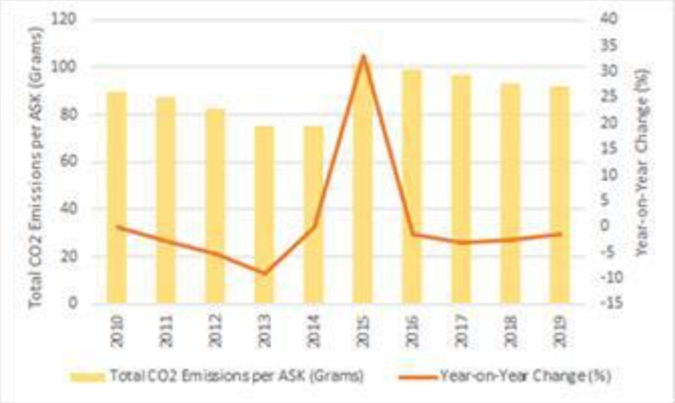

Fig.7: Finnair's total annual carbon dioxide (CO2) emissions per available seat kilometre (ASK): 2010-2019. Data derived from Finnair (2013, 2015, 2019a, 2019b, 2020b).

4.4 Acquisition of a Modern, Fuel-Efficient Aircraft Fleet

Modern aircraft are regarded as being more fuel-efficient and quieter than previous generation aircraft, and thus, Finnair's most significant environmental action has been its continuous, ongoing investments in a modern aircraft fleet (Finnair, 2020b). In addition, the next-generation aircraft, such as, the Airbus A350-900XWB, consume around 20–25 per cent less fuel than their predecessors, whilst the aircraft's carbon dioxide (CO_2) emissions decline by a corresponding amount (Finnair, 2019b).

In June 2010, Finnair announced its plans to replace four Boeing 757 aircraft with five Airbus A321 aircraft, fitted with sharklet wingtips, becoming the launch customer for the modified aircraft type. The "Sharklets" are designed to reduce the aircraft's fuel consumption by up to 4% (Kaminski-Morrow, 2010). The "Sharklet" equipped Airbus A321 aircraft has the lowest emissions in its class (Kainulainen, 2013). In September 2013, Finnair took delivery of the first "Sharklets" equipped Airbus A321 aircraft (Airbus, 2013).

Finnair was also the launch customer for the Airbus A350-900XWB aircraft, and in 2007 placed an order for 11 aircraft, with the option to acquire a for further eight (Airbus, 2014). The fleet investment, which was the most significant in the company's history, saw Finnair take delivery of a total of 19 Airbus A350-900 XWB aircraft. These aircraft support the company's target of reducing carbon dioxide (CO_2) emissions by 17% per cent per revenue tonne kilometre (RTK) flown by the end of 2020, using 2013 as the baseline year (Finnair, 2019b). Revenue tonne kilometres are the product of the revenue earning load as measured in tonnes and the distance over which the revenue load was carried (Cole, 2001). A revenue tonne kilometre (RTK) is one tonne carried one kilometre (Holloway, 2016).

In September 2013, Finnair made important progress toward the company's twin goals of fuel-efficiency and greener operations when it became the world's first commercial operator of Airbus A321 aircraft equipped with new, fuel-saving Sharklet wing tip devices. A total of three Airbus A321s with Sharklets entered the fleet in 2013 (Finnair, 2014). During 2014, Finnair retired the last of its Boeing B757 aircraft and replaced these with Airbus A321 equipped with the new, fuel saving Airbus A321 aircraft equipped with the "Sharklet" winglets (Finnair, 2015). During 2015, Finnair took delivery of its first Airbus A350-900XWB aircraft on 7 October 2015 (Finnair, 2016). Finnair took delivery of four new Airbus A350-900 XWB aircraft during 2016. The airline had a fleet of seven of these aircraft as at the end of 2016. During 2016, three Airbus A340-300 widebody aircraft and two Embraer E170 narrow body aircraft were retired from the airline's fleet (Finnair, 2017).

In 2017, Finnair completed the first phase of its long-haul aircraft fleet renewal, when four new Airbus 350-900XWB aircraft joined the fleet, increasing the number of Airbus 350-900XWB to eleven. Finnair also took delivery of seven new leased Airbus A321 aircraft (Finnair, 2018a). In addition to one new Airbus A350-900XWB aircraft, the airline also added one new Airbus A321 to its fleet in 2018 (Finnair, 2019b). Finnair added two new A350-900XWB aircraft in 2019, bringing its total fleet of A350s to 14 (Finnair, 2020b).

During the period 2020-2025, Finnair will be investing a further € 3.5-4 billion on aircraft fleet renewal and growth. Finnair envisages that its fleet renewal will reduce carbon dioxide (CO_2) emissions on its European services by 10-15% per annum (Finnair, 2020b; Otley, 2020). The new Airbus A350-900XWB aircraft will also enable Finnair to reduce its carbon dioxide (CO_2) emissions on the routes that the aircraft are operated on.

4.5 Finnair Fuel Efficiency Measures to Mitigate Greenhouse (GHG) Gas Emissions

Finnair monitors the fuel efficiency of its flights principally by the aircraft payload indicator revenue tonne kilometres (RTK), which considers the passenger load factor, the total enplaned air cargo consignments transported, as well as the distance between the origin and destination of the flight. A revenue tonne-kilometre (RTK) is an output measure in the airline industry and is defined as a tonne of payload flown over one kilometre (Shaw, 2016). Finnair's fuel efficiency is achieved through highly fuel-efficient flight planning, reductions in the weight of the aircraft operated, and operating each flight as fuel efficiently as possible. The airline's pilots play a key role in this as they have a considerable impact on fuel burn, and thus, on the carbon dioxide (CO_2) emissions produced during flights. In addition, the flexible deployment of the Finnair Airbus fleet, makes it possible for Finnair to allocate an optimal aircraft type to each route on any given day of the year (Finnair, 2020b).

As compared with the 2005 fuel efficiency rate, Finnair has improved its aircraft fleets' fuel efficiency by 27.2% over the period 2005 to 2019. This equates to a 2.3% annual reduction (Finnair, 2020b). Considering the relationship between fuel burn and greenhouse gas (GHG) emissions (Craggs & Gilbert, 2018), the fuel efficiency achieved by Finnair will not only result in lower fuel costs but will also lead to lower emissions of greenhouse gases (GHGs) and their associated impact on the environment. Indeed, a 2% increase in Finnair's fuel efficiency corresponds to around 15 million kilograms of annual fuel savings, which in turn equates to a reduction of nearly 50,000 tonnes of carbon dioxide (CO_2) emissions (Finnair, 2015).

4.6 Finnair Sustainable Waste Management Program

As part of its environmental management policy, Finnair has set a goal to include circular economy principles in all its business operations increasing waste recovery, cost efficiency and safety. The airline also plans to reduce the volume of waste generated. As a starting point the airline has prescribed long-term targets aiming for inflight catering sustainability. There have been ongoing actions directed at achieving this goal with some of the first definitive changes being a reduction in the use of single packaged milk, the introduction of cardboard packaged hot meals to replace "cPET" casseroles, the reduction in plastic amenity kits, and redesigning the packaging of the onboard sales selection (the Nordic Kitchen Brand). At the time of the current study, these changes had resulted in the annual reduction of 80.0 tonnes of wastes annually. Furthermore, in adopting and implementing the circular economy principles, Finnair aims to recycle at least 50% of the plastics returning to its Helsinki Airport hub. In addition, recycled materials as part of its service design, for example, salad containers and business class slippers, are being made from recycled polyethylene terephthalate (PET) (Finnair, 2020b).

As a result of contagious animal health concerns and regulations in place some parts of Finnair's waste flows are considered unsafe for material recycling or for biogas production. All in-flight wastes arriving at Helsinki Airport are reused either as energy, heat, biogas, manure, or material, importantly, most importantly, no waste is disposed to landfill (Finnair, 2020b). As previously noted, the disposal of waste to landfill is viewed as being the least preferable method in sustainable waste management (Barlow & Morgan, 2013; Bolton & Rousta, 2019).

The airline's sustainable waste management policy will also play an important role in the airline achieving its objective of being "carbon neutral" by 2045. In this regard, Finnair (2021b) aims to reduce at least 50% of single-use plastics out of the business by the end of 2022. This will enable the airline to reduce its annual plastic waste by 230 tons. Finnair also plans to reduce its food waste by 50% in the same period (Finnair, 2021b; Otley, 2020). To offset carbon dioxide (CO_2) emissions that are produced from meat production whilst also catering for changing tastes, more vegetarian options will be offered to passengers during 2020 (Green Air, 2020).

4.7 Finnair Use of Sustainable Aviation Biofuels

As previously noted, in recent times, there has been an increasing trend by airlines to use aviation biofuel as an environment sustainability measure (Baxter et al., 2020). Finnair is an active member of the "Nordic Initiative for Sustainable Aviation Working Group". This working group is comprised of Nordic-based airlines, airport operators and government ministries who are working together with aircraft manufacturers to rapidly develop biofuel in the aviation industry (Finnair, 2020b).

Finnair first operated flights using biofuel in 2011, On 23 September 2014, Finnair's flight from Helsinki to New York was operated using a more environmentally friendly biofuel mixture that was partly manufactured from used cooking oil (Finnair, 2015).

In December 2019, Finnair announced that it would be contributing funding, along with other companies, that include Neste, to a feasibility study on a potential synthetic fuels pilot production plant in Eastern Finland. The industrial-scale pilot facility is based on power-to-x technology and the plant will be used to produce carbon-neutral fuels for transportation. The main raw materials that will be used will be excess hydrogen produced by chemical company Kemira and carbon dioxide (CO_2) from the Finnsementii cement facility, which is in Lappeenranta, located in southeastern Finland. Hydrogen and carbon dioxide (CO_2) can be combined in a synthesis process to provide synthetic methanol. This methanol can subsequently be further processed into synthetic, emission-free transportation fuels (Green Air, 2020).

Also, during 2019, Finnair operated three biofuel powered flights, reducing carbon dioxide (CO_2) emissions by 81.8 tonnes (Finnair, 2020b, 2021a). As an element of its "Push for change" initiative launched in early 2019, Finnair used sustainable aviation fuels sourced from used cooking oil on two flights from San Francisco to Helsinki under a purchase agreement with Shell, World Energy and SkyNRG (Green Air, 2020).

At the time of the present study, Finnair was increasing its use of sustainable aviation fuels. By the end of 2025, the airline anticipates spending around €10 million annually on sustainable aviation fuels. Finnair's aviation biofuel partner is Finland-based Neste, the world's largest producer of sustainable aviation fuels that are refined from waste. In addition, Finnair in conjunction with Neste and Finavia, are developing a model which will enable corporate customers to decrease the carbon dioxide (CO_2) emissions of their travel using biofuel (Finnair, 2020b; Green Air, 2020).

4.8 Finnair Use of Biodiesel for Ground Vehicles and Ground Service Equipment (GSE)

Prior to examining Finnair's strategy to mitigate carbon dioxide (CO_2) emissions from its ground operations, it is important to note that a range of functions are performed during the time that that an aircraft spends on the ground and is being serviced in between flights. These functions include any combination or singular selection of the following activities: aircraft loading/unloading, cargo handling, lavatory services, aircraft marshalling, aircraft towing or pushback, aircraft fueling; and auxiliary ground power support (Thompson, 2007). To perform ground handling services, sophisticated technical equipment is required (Kazda & Caves, 2015; Roberts, 2018). This ground service equipment is typically powered by diesel engines. Vehicles used by airlines are also often petrol-powered.

Finnair's environmental policy has included replacing the use of fossil fuels in ground vehicles and ground service equipment (GSE) with biodiesel powered equipment and vehicles. During 2019, all Finnair's diesel driven ground service vehicles were running on biodiesel. This resulted in an annual reduction of 155 tonnes of carbon dioxide (CO_2) emissions (Finnair, 2020b). Biofuels can reduce a firm's consumption of fossil fuels, and hence, reduce carbon dioxide (CO_2) emissions. This is because biofuels are carbon neutral (Hanaki & Portugal-Pereira, 2018). Finnair is also using some electric powered ground vehicle and ground service equipment (GSE) fleet (Finnair, 2020b).

4.9 Passenger Carbon Dioxide (CO2) Emissions Offset Scheme

Finnair has introduced a carbon offsetting scheme for its passengers, whereby passengers can offset their carbon dioxide (CO_2) emissions through an emissions reduction project, and/or using sustainable aviation biofuels. Effective 1 September 2020, Finnair plans to offset carbon dioxide (CO_2) emissions from its corporate customers. Finnair will also introduce new types of passenger tickets that will permit passengers to support aviation biofuels or other offsetting measures during 2020 (Finnair, 2021d).

4.10 Reductions in Aircraft Weight

Finnair has implemented a program to reduce the weight of its fleet of aircraft, as this weight reduction has a direct impact on fuel burn, and thus, aircraft emissions (Finnair, 2021a). The use of new technology and high-quality lightweight materials has enabled Finnair to reduce the empty weight of its aircraft. For instance, in 2014, Finnair replaced all its baggage containers used on its narrow body aircraft with lightweight composite containers. In addition, weight is considered one of the key considerations in all procurement activities related to aircraft-related equipment (Finnair, 2015).

Finnair has developed a new plan to remove unnecessary weight from the airline's aircraft, with a target of reducing fuel consumption by 15,000 tonnes per year (Green Air, 2020). As of the end of April 2020, Finnair will remove travel retail sales from its short-haul European services and instead will focus on pre-orders (Preston, 2020). This policy is expected to reduce on average 50-100 kg per flight and will result in a 70,000 kg saving in fuel consumption and 220,000 kg of carbon dioxide (CO_2) emissions per year (Green Air, 2020).

4.11 Implementation of the United Nations Sustainable Development Goals (SDGs)

In 2015, all United Nations Member States adopted the "2030 Agenda for Sustainable Development" and its seventeen 17 Sustainable Development Goals (SDGs). Each SDG comprises a range of targets to be achieved by 2030 (Katila et al., 2019; United Nations, 2021). The United Nations Sustainable Development Goals (SDGs) provide a framework for business and government to solve global economic, social, and environmental challenges (Air New Zealand, 2018).

At the time of the present study, Finnair was contributing to all 17 Sustainable Development Goals (SDGs). The company has chosen to particularly focus on six SDGs which are the most relevant for its business: gender equality (SDG 5), industry innovation and infrastructure (SDG 9), responsible consumption and production (SDG 12), climate action (SDG 13), peace, justice, and strong institutions (SDG 16), and partnerships for the goals (SDG 17) (Finnair, 2021e). The SDG most pertinent to this study is SDG 13, that is, to take urgent action on climate change.

V. CONCLUSION

In conclusion, this study has examined the strategies defined and implemented by Finnair to meet its objective of becoming a “carbon neutral” airline by 2045. To achieve the objectives of the study, Finnair was selected as the case airline. The research was undertaken using an in-depth qualitative instrumental case study research approach. All the data collected for the study was examined using document analysis. The study was underpinned by a case study research framework that followed the recommendations of Yin (2018).

Finnair has defined and is implementing a range of strategies and environmental-related measures to meet its objective of becoming a “carbon neutral” airline by 2045. The airline has introduced a carbon offsetting scheme for its passengers, whereby passengers can offset their carbon dioxide (CO_2) emissions through an emissions reduction project, and/or using sustainable aviation biofuels. Sustainable waste management is another important element in Finnair’s goal to become a carbon neutral airline by 2045. Wherever possible, Finnair is planning to recycle at least 50% of the plastics returning on its flights to its home base at Helsinki Vantaa Airport. Importantly, no waste is disposed by landfill; this practice eliminates the greenhouse gases associated with landfill waste, and thus helps alleviate climate change. Finnair is also planning to reduce its food waste by 50% and to reduce single use plastics by 50% as well by the end of 2022. Another important strategy implemented by Finnair is the increased use of sustainable aviation biofuels. Aviation biofuels are an important substitute for fossil-based fuel as they are more environmentally friendly and offer airlines the chance to decarbonize their operations. Finnair’s environmental policy has included the replacement of fossil fuels in its ground service equipment (GSE) and ground vehicles with biodiesel. The use of biodiesel is producing annual reductions in the airline’s ground service equipment (GSE) and ground vehicles carbon dioxide (CO_2) emissions. Another important measure adopted by Finnair has been to reduce the weight of its aircraft. In this regard, Finnair is using new technology and high-quality lightweight materials where possible.

The case study revealed that the acquisition and deployment of modern, fuel-efficient aircraft have underpinned Finnair’s goal to become a carbon neutral airline. The operation of modern fuel-efficient aircraft is the airline’s most significant environmental action and forms a key part of the airline’s sustainability strategy. The airline’s fleet of modern, state-of-the art, Airbus A350-900XWB aircraft consume around 20-25% less fuel than their predecessors, and very importantly, their carbon dioxide (CO_2) emissions decline by a corresponding amount. Also, as noted in the case study, Finnair took delivery of a fleet of Airbus A321 aircraft equipped with the “Sharklet” wing tips. These aircraft have the lowest emissions in their class.

The burning of aviation fuel results in the emissions of carbon dioxide (CO_2) and other harmful gases. Thus, fuel efficiency has a concomitant impact on aircraft emissions. Finnair places a very high focus on fuel efficiency, and this is achieved through optimized flight planning, reductions in aircraft weight, and the flexible deployment of its aircraft fleet.

As noted in the case study, virtually all of Finnair’s greenhouse gas emissions come from its flight operations. Over the study period, Finnair expanded its route network and aircraft fleet, and, as a result, there was an associated increase in the airline’s Scope 1 carbon dioxide (CO_2) emissions from jet fuel usage. These emissions grew from 2,220,388 tonnes of carbon dioxide (CO_2) in 2010 to 3,566,409 tonnes of carbon dioxide (CO_2) in 2019. Finnair’s annual Scope 1 carbon dioxide (CO_2) emissions from fuel used for its ground service equipment (GSE) and ground vehicles declined from a high of 5,181 tonnes of carbon dioxide (CO_2) in 2010 to 668 tonnes of carbon dioxide (CO_2) in 2010. Finnair is transitioning from diesel powered vehicles to electric powered vehicles, and these will deliver more favorable environmental benefits. Finnair’s annual Scope 2 carbon dioxide (CO_2) emissions from electricity oscillated over the study period with annual increases being recorded in 2011, 2012, 2016, 2017, and 2018. In 2019, Finnair’s annual Scope 2 carbon dioxide (CO_2) emissions from electricity amounted to 7,068 tonnes of carbon dioxide (CO_2), this was the second lowest level of emissions recorded during the study period. Finnair’s annual Scope 2 emissions from the heating of its facilities also oscillated during the study period. There were large spikes in emissions during the cold winters experienced in Finland. Conversely, during more mild winters there was a decline in carbon dioxide emissions (CO_2) due to the lower heating requirements. During the period 2015 to 2019, Finnair’s annual Scope 3 carbon dioxide (CO_2) emissions exhibited an upward trend, increasing from 567,902 tonnes of carbon dioxide (CO_2) in 2015 to 770,802 tonnes of carbon dioxide (CO_2) in 2019. The airline’s annual Scope 3 carbon dioxide (CO_2) emissions were impacted by a range of factors which included the estimated tonnage of carbon dioxide (CO_2) emissions associated with the manufacture of the airline’s new Airbus A350-900XWB aircraft, the greenhouse gas (GHG) emissions associated with the production and transportation of jet fuel, emissions from leased vehicles, and emissions from cargo flights that were operated on behalf of Finnair Cargo.

REFERENCES

[1] Abdullah, M.A., Chew, B.C., & Hamid, S.R. (2016). Benchmarking key success factors for the future green airline industry. *Procedia - Social and Behavioral Sciences*, 224, 246 – 253. https://doi.org/10.1016/j.sbspro.2016.05.456

[2] Agarwal, R.K. (2009). Sustainable (green) aviation: Challenges and opportunities. *SAE International Journal of Aerospace*, 2(1), 1-20. https://doi.org/10.4271/2009-01-3085

[3] Agarwal, R.K. (2012). Review of technologies to achieve sustainable (green) aviation. In R.K. Agarwal (Ed.), *Recent advances in aircraft technology* (pp. 427-464). Rijeka, Croatia: InTech.

[4] Air New Zealand. (2018). Sustainability report 2018. Retrieved from https://www.airnewzealand.com.au/sustainability-reporting-and-communication.

[5] Airbus. (2013). Finnair receives world's first A321 with Sharklets. Retrieved from https://www.airbus.com/newsroom/press-releases/en/2013/09/finnair-receives-world-s-first-a321-with-sharklets.html.

[6] Airbus. (2014). Finnair orders eight additional A350 XWBs. Retrieved from https://www.airbus.com/newsroom/press-releases/en/2014/12/finnair-orders-eight-additional-a350-xwbs.html.

[7] Air Transport Action Group. (2020). Finnair's anti-carbon program lifts the ambition-level in the aviation industry. Retrieved from https://aviationbenefits.org/newswire/2020/03/finnairs-anti-carbon-program-lifts-the-ambition-level-in-the-aviation-industry/.

[8] Attanasio, G. (2018). Naples International Airport and Airport Carbon Accreditation (ACA). In J. Casares., J. Longhurst., G, Passerini., G. Perillo & J. Barnes (Eds), *WIT transactions on ecology and the environment: Air pollution XXVI* (pp. 465-474). Southampton, UK: WIT Press.

[9] Babakhani, N., Ritchie, BW., & Dolnicar, S. (2017). Improving carbon offsetting appeals in online airplane ticket purchasing: Testing new messages and using new test methods. *Journal of Sustainable Tourism*, 25(7), 955-969. https://doi.org/10.1080/09669582.2016.1257013

[10] Bailey, J. (2020). Finnair aims to cut emissions by 50% in just 5 years. Retrieved from https://simpleflying.com/finnair-aims-to-cut-emissions-by-50-in-just-5-years/.

[11] Barlow, C.Y., & Morgan, D.C. (2013). Polymer film packaging for food: An environmental assessment. *Resources, Conservation and Recycling*, 78, 74-80. https://doi.org/10.1016/j.resconrec.2013.07.003

[12] Barrett, S.R.H., Britter, R.E., & Waitz, I.A. (2010). Global mortality attributable to aircraft cruise emissions. *Environmental Science & Technology*, 44(19), 7736-7742. https://doi.org/10.1021/es101325r

[13] Bauen, A., & Nattrass, L. (2018). Sustainable aviation biofuels: Scenarios for deployment. In M. Kaltschmitt & U. Neuling (Eds.), *Biokerosene: Status and prospects* (pp. 703-721). Berlin, Germany: Springer-Verlag.

[14] Baxter, G. (2016). *AERO2410 Airline Operations: Topic 6 Learning Guide Airline Capacity Management and Passenger Aircraft Fleet Planning*. Melbourne, Australia: RMIT University.

[15] Baxter, G. (2021). Mitigating an airport's carbon footprint through the use of "green" technologies: The case of Brisbane and Melbourne Airports, Australia. *International Journal of Environment, Agriculture and Biotechnology*, 6(6), 29-39. https://dx.doi.org/10.22161/ijeab.66.4

[16] Baxter, G., Srisaeng, P., & Wild, G. (2018). Sustainable airport waste management: The case of Kansai International Airport. *Recycling*, 3(1), 6. https://doi.org/10.3390/recycling3010006

[17] Baxter, G., Srisaeng P, & Wild G. (2020). The use of aviation biofuels as an airport environmental sustainability measure: The case of Oslo Gardermoen Airport. *Magazine of Aviation Development*, 8(1), 6-17. https://doi.org/10.14311/MAD.2020.01.01

[18] Baxter, G., Srisaeng, P., & Wild, G. (2021). Environmentally sustainable airline waste management: The case of Finnair PLC. *Environmental Research, Engineering and Management*, 77(4), 73-85. https://doi.org/10.5755/j01.erem.77.4.29574

[19] Bayon, R., Hawn, A., & Hamilton, K. (2009). *Voluntary carbon markets: An international business guide to what they are and how they work*. London, UK: Earthscan.

[20] Becken, S. (2020). Major airlines say they're acting on climate change, but research reveals they're way off course. Retrieved from https://www.abc.net.au/news/2020-02-17/are-major-airlines-doing-enough-to-act-on-climate-change/11966892.

[21] Becken, S., & Mackey, B. (2017). What role for offsetting aviation greenhouse gas emissions in a deep-cut carbon world? *Journal of Air Transport Management*, 63, 71-84. https://doi.org/10.1016/j.jairtraman.2017.05.009

[22] Bioenergy International. (2019). Finnair introduces carbon offsetting and biofuel service for customers. Retrieved from https://bioenergyinternational.com/markets-finance/finnair-introduces-carbon-offsetting-and-biofuel-service-for-customers.

[23] Birchfield, V.L. (2015). Coercion with kid gloves? The European Union's role in shaping a global regulatory framework for aviation emissions. *Journal of European Public Policy*, 22(9), 1276-1294. https://doi.org/10.1080/13501763.2015.1046904

[24] Bolton, K., & Rousta, K. (2019). In M.J. Taherzadeh, K. Bolton, J. Wong & A. Pandey (Eds.), *Sustainable resource recovery and zero waste approaches* (pp. 53-63). Amsterdam, The Netherlands: Elsevier.

[25] Brimson, S. (1985). *The airlines of the world*. Sydney, Australia: Dreamweaver Books.

[26] Brooks, K.P., Snowden-Swan, l.J., Jones, S.B., Butcher, M.J., Lee, J.S.J., Anderson, D.M., Frye, J.G., Holladay, J.E., Owen, J., Harmon, L., Burton, F., Palou-Rivera, I., Plaza, J., Handler, R., & Shonnard, D. (2016). Low-carbon aviation fuel through the alcohol to jet pathway. In C. Chuck (Ed.), *Biofuels for aviation: Feedstocks, technology and implementation* (pp. 109-146). London, UK: Academic Press.

[27] Budd, T. (2017). Environmental impacts and mitigation. In L. Budd & S. Ison (Eds.), *Air transport management: An international perspective* (pp. 283-306). Abingdon, UK: Routledge.

[28] Budd, T., Intini, M., & Volta, N. (2020). Environmentally sustainable air transport: A focus on airline productivity. In T. Walker, A.S. Bergantino., N. Sprung-Much & L Loiacono (Eds.), *Sustainable aviation: Greening the flight path* (pp. 55-77). Cham, Switzerland: Palgrave Macmillan.

[29] Centre for Aviation. (2020). Finnair to reduce net emissions by 2025, achieve carbon neutrality by 2045. Retrieved from https://centreforaviation.com/analysis/reports/aviation-sustainability-and-the-environment-capa-09-mar-2020-516511.

[30] Chandrappa, R., & Das, D.B. (2012). *Solid waste management: Principles and practice*. Berlin, Germany: Springer Verlag.

[31] Chant, C. (1997). *Airlines of the world*. London, UK: Tiger Books International.

[32] Chen, F. Y. (2013). The intention and determining factors for airline passengers' participation in carbon offset schemes. *Journal of Air Transport Management*, 29, 17-22. https://doi.org/10.1016/j.jairtraman.2013.01.001

[33] Climates to Travel. (2021). Climate – Finland. Retrieved from https://www.climatestotravel.com/climate/finland.

[34] Cole, S. (2001). *Applied transport economics: Policy, management and decision making* (2nd ed.). London, UK: Kogan Page.

[35] Craggs, L., & Gilbert, P. (2018). Sustainable greenhouse gas reductions from bioenergy systems - Climate change: A bioenergy driver and constraint. In P. Thornley & P. Adams (Eds.), *Greenhouse gas balances of bioenergy systems* (pp. 1-10). London, UK: Academic Press.

[36] Cui, Q., & Li, X.Y. (2021). Which airline should undertake a large emission reduction allocation proportion under the "carbon neutral growth from 2020" strategy? An empirical study with 27 global airlines. *Journal of Cleaner Production*, 279, 123745. https://doi.org/10.1016/j.jclepro.2020.123745

[37] Cui, Q., Lin, J.L., & Jin, Z.Y. (2020). Evaluating airline efficiency under "Carbon Neutral Growth from 2020" strategy through a Network Interval Slack-Based Measure. *Energy*, 193, 116734. https://doi.org/10.1016/j.energy.2019.116734

[38] Czerny, A.I., Fu, X., Lei, Z., & Oum, T.H. (2021). Post pandemic aviation market recovery: Experience and lessons from China. *Journal of Air Transport Management*, 90, 101971. https://doi.org/10.1016/j.jairtraman.2020.101971

[39] Dileep, M.R., & Kurien, A. (2022). *Air transport and tourism: Interrelationship, operations and strategies*. Abingdon, UK: Routledge.

[40] Dodd, T., & Yengin, D. (2021). Deadlock in sustainable aviation fuels: A multi-case analysis of agency. *Transportation Research Part D: Transport and Environment*, 94, 102799. https://doi.org/10.1016/j.trd.2021.102799

[41] Dodd, T., Orlitzky, M., & Nelson, T. (2018). What stalls a renewable energy industry? Industry outlook of the aviation biofuels industry in Australia, Germany, and the USA. *Energy Policy*, 123, 92-103. https://doi.org/10.1016/j.enpol.2018.08.048

[42] Drewer, J., Howard, D., & McNamara, N. (2018). Greenhouse gas (GHG) and biogenic volatile organic compound (bVOC) fluxes associated with land-use change to bio-energy crops. In P. Thornley & P. Adams (Eds.), *Greenhouse gas balances of bioenergy systems* (pp. 77-96). London, UK: Academic Press.

[43] Dryer, J.E. (2017). Perspectives on the future of green aviation. In E.S. Nelson & D.R. Reddy (Eds.), *Green aviation: Reduction of environmental impact through aircraft technology and alternative fuels*. (pp. 335-346). London, UK: CRC Press/Balkema.

[44] Ehmer, H., Berster, P., Bischoff, G., Grimme, W., Grunewald, E. & Maertens, S. (2008). Analyses of the European air transport market: Airline business models. Retrieved from https://ec.europa.eu/transport/sites/transport/files/modes/air/doc/abm_report_2008.pdf.

[45] Finnair. (2013). Sustainability report 2012. Retrieved from https.//investors.finnair.com/~/media/Files/F/Finnair-IR/documents/en/reports-and-presenntation/2013/Finnair-sustainability-report-2012.pdf.

[46] Finnair. (2014). Annual Report 2013. Retrieved from https://investors.finnair.com/~/media/F/Files/Finnair-IR/documents/en/reports-and-presentation/2014/annual-report-2013.pdf.

[47] Finnair. (2015). Annual report 2014. Retrieved from https://investors.finnair.com/~/media/F/Files/Finnair-IR/dcouments/en/reports-and-presentation/2015/annual-report-2014.pdf.

[48] Finnair. (2016). Finnair Group interim report 1 January – 30 September 2015. Retrieved from https://investors.finnair.com/~/media/Files/F/Finnair-IR/documents/en/reports-and-presentation/2015/finnair-q3-2015-interim-report.pdf.

[49] Finnair. (2017). Annual report 2016. Retrieved from https://investors.finnair.com/~/media/F/Files/Finnair-IR/dcouments/en/reports-and-presentation/2017/annual-report-2016.pdf.

[50] Finnair. (2018a). Annual report 2017.Retrieved from https://investors.finnair.com/~/media/F/Files/Finnair-IR/dcouments/en/reports-and-presentation/2018/annual-report-2017.pdf.

[51] Finnair. (2018b). Finnair environmental history: Major green milestones. Retrieved from https://cargo.finnair.com/en/cargo-news/environment-sustainability-results.

[52] Finnair. (2019a). Financial information 2018. Retrieved from https://investors.finnair.com/~/media/F/Files/Finnair-IR/dcoumemts/en/financial/finnair-2018-en.pdf.

[53] Finnair. (2019b). Sustainability report 2018. Retrieved from https://investors.finnair.com/~/media/Files/F/Finnair-IR/documents/en/reports-and-presentation/2019/Finnair-sustainability-report-2018.pdf.

[54] Finnair. (2020a). Annual report 2019. Retrieved from https://investors.finnair.com/~/media/F/Files/Finnair-IR/dcoumemts/en/reports-and-presentation/2020/annual-report-2019.pdf.

[55] Finnair. (2020b). Sustainability report 2019. Retrieved from https://company.finnair.com/resource/blob/1994132/c493686a5af678b81ed6dbcd48eed150/fiinair-responsibility-report-2019-data.pdf.

[56] Finnair. (2021a). CO_2 reduction. Retrieved from: https://company.finnair.com/en/sustainability/co2-reduction.

[57] Finnair. (2021b). Finnair's anti-carbon program lifts the ambition-level in the aviation industry, Media Release March 06. Retrieved from https://company.finnair.com/en/media/all-releases/news?id=3593081.

[58] Finnair. (2021c) Finnair fleet. Retrieved from https://www.finnair.com/au/gb/flights/fleet.

[59] Finnair. (2021d). How Finnair is putting sustainability at its core. Retrieved from https://www.finnair.com/au-en/bluewings/sustainability/how-finnair-is-putting-sustainability-at-its-core-2053792.

[60] Finnair. (2021e). Sustainability. Retrieved from: https://company.finnair.com/en/sustainability.

[61] Finnish Meteorological Institute. (2011). 2010 – a year of weather extremes. Retrieved from https://en.ilmatieteenlaitos.fi/press-release/125205.

[62] Fregnani, A.T.G., & Andrade, O. (2017). Aviation initiatives and the relative impact of electric road vehicles on CO_2 emissions. Retrieved from https://www.boeing.com/features/innovation-quarterly/aug2017/feature-technical-co2.page.

[63] Fulekar, M.H. (2010). *Environmental biotechnology*. Boca Raton, FL: AK Peters/CRC Press.

[64] Gegg, P., Budd, L., & Ison, S. (2014). The market development of aviation biofuel: Drivers and constraints. *Journal of Air Transport Management*, 39, 34-40. https://doi.org/10.1016/j.jairtraman.2014.03.003

[65] Gellings, C.W. (2011). *Saving energy and reducing CO_2 emissions with electricity*. Lilburn, GA: The Fairmont Press.

[66] Girella, L. (2018). *The boundaries in financial and non-financial reporting: A comparative analysis of their constitutive role*. Abingdon, UK: Routledge.

[67] Grandy, G. (2010). Instrumental case study. In A.J. Mills., G. Durepos., & E. Wiebe (Eds.), *Encyclopedia of case study research*, Volume 1 (pp. 473-475). Thousand Oaks, CA: SAGE Publications.

[68] Grant, A. (2019). *Doing excellent social research with documents: Practical examples and guidance for qualitative researchers*. Abingdon, UK: Routledge.

[69] Green Air. (2020). Finnair signs SAF agreement with Neste as it targets a 50 per cent reduction of net emissions by 2025. Retrieved from https://www.greenaironline.com/news.php?viewStory=2625.

[70] Green, W., & Swanborough, G. (1975). *The Observer's world airlines and airliners directory*. London, UK: Frederick Warne & Company Limited.

[71] Greenhouse Gas Protocol. (2021). About us. Retrieved from https://ghgprotocol.org/about-us.

[72] Hagmann, C., Semeijn, J., & Vellenga, D.B. (2015). Exploring the green image of airlines: Passenger perceptions and airline choice. *Journal of Air Transport Management*, 43, 37-45. https://doi.org/10.1016/j.jairtraman.2015.01.003

[73] Hanaki, K., & Portugal-Pereira, J. (2018). The effect of biofuel production on greenhouse gas emission reductions. In K.Takeuchi., H. Shiroyama,, O. Saito & M. Matsuura (Eds.), *Biofuels and sustainability: Holistic perspectives for policymaking* (pp. 53-71). Tokyo, Japan: Springer Japan KK.

[74] Harper, M. (2004). Introduction. In M. Ali (Ed.), *Sustainable composting: Case studies and guidelines for developing countries* (pp. 3-4). Loughborough, UK: Water, Engineering and Development Centre.

[75] Harris, N. (2019). *Green chemistry*. Waltham, UK: ED-Tech-Press.

[76] Hayward, J. (2019). The story of the oneworld Alliance. Retrieved from https://simpleflying.com/oneworld-alliance-story/.

[77] Heshmati, A., & Kim, J. (2016). *Efficiency and competitiveness of international airlines*. Singapore: Springer Science+Business Media.

[78] Holloway, S. (2016). *Straight and level: Practical airline economics* (3rd ed.). Abingdon, UK: Routledge.

[79] International Air Transport Association. (2016). IATA carbon offset program: Frequently asked questions. Retrieved from http://www.iata.org/contentassets/922ebc4cbcd24c4d9fd55933e7070947/icop20faq20general20for20airline20particpants20jan202016.pdf.

[80] International Air Transport Association. (2018). Climate change & CORSIA. Retrieved from https://www.iata.org/contentassets/c4f9f0450212472b96dac114a06cc4fa/fact-sheet-climate-change.pdf.

[81] International Air Transport Association. (2021a). Airline cabin waste. Retrieved from https://www.iata.org/en/policy/environment/cabin-waste/.

[82] International Air Transport Association. (2021b). IATA Carbon Offset Program. Retrieved from

https://www.iata.org/en/programs/environment/carbon-offset/.

[83] International Airport Review. (2010). UK airport operators launch new guidelines to reduce aircraft ground emissions. Retrieved from http://www.internationalairportreview.com/2717/airport-news/uk-airport-operators-launch-new-guidelines-to-reduce-aircraft-ground-emissions/.

[84] International Civil Aviation Organization. (2011). *Airport air quality manual*. Document No 9889. Montreal, Canada: ICAO.

[85] International Civil Aviation Organization. (2021). What are the mechanisms for the CORSIA implementation? How will ICAO support States to implement the CORSIA? Retrieved from https://www.icao.int/environmental-protection/Pages/A39_CORSIA_FAQ4.aspx.

[86] International Organization for Standardization. (2014). ISO 6966-2:2014(en) Aircraft ground equipment — Basic requirements — Part 2: Safety requirements. Retrieved from https://www.iso.org/obp/ui/#iso:std:iso:6966:-2:ed-2:v1:en.

[87] Jalalian, M., Gholami, S., & Ramezanian, R. (2019). Analyzing the trade-off between CO_2 emissions and passenger service level in the airline industry: Mathematical modeling and constructive heuristic. *Journal of Cleaner Production*, 206, 251-266. https://doi.org/10.1016/j.jclepro.2018.09.139

[88] Javed, T., Ahmed, A., Raman, V., Alqualty, A.B.S., & Johansson, B. (2019). Combustion-based transportation in a carbon constrained world – A review. In R.A. Agarwal., A.K. Agarwal., T. Gupta & N. Sharma (Eds.), *Pollutants from energy sources: Characterization and control* (pp. 7-34). Singapore: Springer Nature Singapore.

[89] Jones, M. (2009). *Sustainable event management: A practical guide* (2nd ed.). Abingdon, UK: Routledge.

[90] Kainulainen, M. (2013). Finnair receives world's first Airbus A321 with Sharklets. Retrieved from https://www.helsinkitimes.fi/business/7600-finnair-receives-world-s-first-airbus-a321-with-sharklets.html.

[91] Kaminski-Morrow, D. (2010). Finnair scraps order for two A330s to launch sharklet A321. Retrieved from https://www.flightglobal.com/finnair-scraps-order-for-two-a330s-to-launch-sharklet-a321/94025.article.

[92] Katila, P., Pierce Colfer, C.J., de Jong, W., Galloway, G., Pacheco, P., & Winkel, G. (2019). Introduction. In P. Katila., C.J. Pierce., C.J. Colfer., W. de Jong., G. Galloway., P. Pacheco & G. Winkel (Eds.), *Sustainable development goals* (pp. 1-16). Cambridge, UK: Cambridge University Press.

[93] Kazda, A., & Caves, R.E. (2015). *Airport design and operation* (3rd ed.). Bingley, UK: Emerald Group Publishing.

[94] Kitamura, K. (2019). A conceptual framework for managerial analysis under economic nationalism and globalization: A study of Japanese automakers in the USA. In H. Chandan & B. Christiansen (Eds.), *International firms' economic nationalism and trade policies in the globalization era* (pp. 35-58). Hershey, PA: IGI Global.

[95] Levin, K., Song, J., & Morgan, J. (2015). COP21 Glossary of terms guiding the long-term emissions-reduction goal. Retrieved from https://www.wri.org/blog/2015/12/cop21-glossary-terms-guiding-long-term-emissions-reduction-goal.

[96] Levy, J.I., Woody, M., Haeng Baek, B., Shankar, U., & Arunachalam, S. (2012). Current and future particulate-matter-related mortality risks in the United States from aviation emissions during landing and takeoff. *Risk Analysis: An International Journal*, 32(2), 237-249. https://doi.org/10.1111/j.1539-6924.2011.01660.x

[97] Li, X.Y., & Tang, B.J. (2017). Incorporating the transport sector into carbon emission trading scheme: An overview and outlook. *Natural. Hazards*, 88, 683–698. https://doi.org/10.1007/s11069-017-2886-3

[98] Li, Z. (2021). Air emergency transport under COVID-19: Impact, measures, and future. *Journal of Advanced Transportation*, 2021, 5560994. https://doi.org/10.1155/2021/5560994

[99] Liu, J., Qiao, P., Ding, J., Hankinson, L., Harriman, E.H., Schiller, E.M., Ramanauskaite, L., & Zhang, H. (2020). Will the aviation industry have a bright future after the COVID-19 Outbreak? Evidence from Chinese airport shipping sector. *Journal of Risk and Financial Management*, 13(11), 276. https://doi.org/10.3390/jrfm13110276

[100] Maertens, S., Grimme, W., Scheelhaase, J., & Jung, M. (2019). Options to continue the EU ETS for aviation in a CORSIA-world. *Sustainability*, 11(20), 5703. https://doi.org/10.3390/su11205703

[101] Manahan, S. E. (2011). *Fundamentals of environmental chemistry* (3rd ed.). Boca Raton, FL: CRC Press.

[102] Markham, F., Young, M., Reis, A., & Higham, J. (2018). Does carbon pricing reduce air travel? Evidence from the Australian 'Clean Energy Future' policy, July 2012 to June 2014. *Journal of Transport Geography*, 70, 206-214. https://doi.org/10.1016/j.jtrangeo.2018.06.008

[103] Mazhar, M.U., Bull, R., Lemon, M., & Bin Saleem Ahmad, S. (2019). Carbon management planning in UK universities: A journey to low carbon-built environment. In W. Leal Filho & R. Leal-Arcas (Eds.), *University initiatives in climate change mitigation and adaptation* (pp. 33-56). Cham, Switzerland: Springer International Publishing.

[104] Meleo, L., Nava, C.R., & Pozzi, C. (2016). Aviation and the costs of the European Emission Trading Scheme: The case of Italy. *Energy Policy*, 88, 138-147. https://doi.org/10.1016/j.enpol.2015.10.008

[105] Migdadi, Y.K.A.A. (2018). Identifying the best practices of airlines' green operations strategy: A cross-regional worldwide survey. *Environmental Quality Management* 28(1), 21.32. https://doi.org/10.1002/tqem.21575

[106] Migdadi, Y.K.A.A. (2020a). *Airline green operational strategies: Emerging research and opportunities*. Hershey, PA: IGI Global.

[107] Migdadi, Y.K.A.A. (2020b). Green operational strategies for airlines: Content and regional analysis. In P. Yang (Ed.), *Cases on green energy and sustainable development* (pp. 193-229). Hershey, PA: IGI Global.

[108] Migdadi, Y.K.A.A. (2020c). Identifying the effective taxonomies of airline green operations strategy. *Management of Environmental Quality*, 31(1), 146-166. https://doi.org/10.1108/MEQ-03-2019-0067

[109] Monios, J. (2016). *Institutional challenges to intermodal transport and logistics: Governance in port regionalization and hinterland integration*. Abingdon, UK: Routledge.

[110] Nava, C.R., Meleo, L., Cassetta, E., & Morelli, G. (2018). The impact of the EU-ETS on the aviation sector: Competitive effects of abatement efforts by airlines. *Transportation Research Part A: Policy and Practice*, 113, 20-34. https://doi.org/10.1016/j.tra.2018.03.032

[111] Neuling, U., & Kaltschmitt, M. (2018). Techno-economic and environmental analysis of aviation biofuels. *Fuel Processing Technology*, 171, 54-69. https://doi.org/10.1016/j.fuproc.2017.09.022

[112] Ngo, C., & Natowitz, J. (2016). *Our energy future: resources, alternatives and the environment*. Hoboken, NJ: John Wiley & Sons.

[113] Niu, S.Y., Liu, C.L, Chang, C.C., & Ke, K.D. (2016). What are passenger perspectives regarding airlines' environmental protection? An empirical investigation in Taiwan. *Journal of Air Transport Management*, 55, 84-91. https://doi.org/10.1016/j.jairtraman.2016.04.012

[114] O'Leary, Z. (2004). *The essential guide to doing research*. London, UK: SAGE Publications.

[115] Otley, T. (2020). Finnair aims for carbon neutrality by 2045. Retrieved from https://www.businesstraveller.com/features/finnair-aims-for-carbon-neutrality-by-2045/.

[116] Palmer, W. (2020). Sustaining flight: Comprehension, assessment, and certification of sustainability in aviation. In T. Walker, A.S. Bergantino., N. Sprung-Much & L. Loiacono (Eds.), *Sustainable aviation: Greening the flight path* (pp. 7-28). Cham, Switzerland: Palgrave Macmillan.

[117] Park, Y., & O'Kelly, M.E. (2014). Fuel burn rates of commercial passenger aircraft: Variations by seat configuration and stage distance. *Journal of Transport Geography*, 41, 137-147. https://doi.org/10.1016/j.jtrangeo.2014.08.017

[118] Pawlowska, M. (2014). *Mitigation of landfill gas emissions*. Leiden, The Netherlands: CRC Press/Balkema.

[119] Pitt, M., & Smith, A. (2003). Waste management efficiency at UK airports. *Journal of Air Transport Management*, 9(2),103-111. https://doi.org/10.1016/S0969-6997(02)00063-7

[120] Preston, A. (2020). Finnair wants to banish its carbon footprint. Retrieved from https://www.inflight-online.com/finnair-wants-to-banish-its-carbon-footprint/.

[121] Rahim, A.R., & Baksh, M.S. (2003). Case study method for product development in engineer-to-order organisations. *Work Study*, 52(1), 25–36. https://doi.org/10.1108/00438020310458705

[122] Rahman, M., Pudasainee, P., & Gupta, R. (2017). Urban waste (municipal solid waste-MSW) to energy. In S. Devasahayam., K. Dowling, & M.K. Mahapatra (Eds.), *Sustainability in the mineral and energy sectors* (pp. 499-530). Boca Raton, FL: CRC Press.

[123] Ramon Gil-Garcia, J. (2012). *Enacting electronic government success: An integrative study of government-wide websites, organizational capabilities, and institutions*. New York, NY: Springer Science-Business Media.

[124] Reinhardt, T., Richers, U., & Suchomel, H. (2008). Hazardous waste incineration in context with carbon dioxide. *Waste Management Research*, 26(1), 88-95. https://doi.org/10.1177%2F0734242X07082339

[125] Ritchie, B.W., Sie, L., Gössling, S., & Dwyer, L. (2020). Effects of climate change policies on aviation carbon offsetting: a three-year panel study. *Journal of Sustainable Tourism*, 28(2), 337-360. https://doi.org/10.1080/09669582.2019.1624762

[126] Roberts, A. (2018). Airside resource planning. In P.J. Bruce., Y. Gao & J.M.C. King (Eds.), *Airline operations: A practical guide* (pp. 152-161.). Abingdon, UK: Routledge.

[127] Roza, G. (2009). *Reducing your carbon footprint on vacation*. New York, NY: The Rosen Publishing Group,

[128] Sales, M. (2013). *Air cargo management: Air freight and the global supply chain*. Abingdon, UK: Routledge.

[129] Sales, M. (2016). *Aviation logistics: The dynamic partnership of air freight and supply chain*. London, UK: Kogan Pace.

[130] Sameh, M.M., & Scavussi dos Santos, J. (2018). Environmental sustainability measures for airports. In A. de Mestral, P.P Fitzgerald & M. Tanveer (Eds.), *Sustainable development, international aviation, and treaty implementation* (pp. 62-80). Cambridge, UK: Cambridge University Press.

[131] Sarkar, A. N. (2012). Evolving green aviation transport system: A Holistic approach to sustainable green market development. *American Journal of Climate Change*, 1, 164-180.

[132] Schäfer, A.W. (2016). The prospects for biofuels in aviation. In C. Chuck (Ed.), *Biofuels for aviation: Feedstocks, technology and implementation* (pp. 3-16). London, UK: Academic Press.

[133] Scheelhaase, J., Maertens, S., Grimme, W., & Jung, M. (2018). EU ETS versus CORSIA – A critical assessment of two approaches to limit air transport's CO_2 emissions by market-based measures. *Journal of Air Transport Management*, 67, 55-62. https://doi.org/10.1016/j.jairtraman.2017.11.007

[134] Scott, B.J., & Trimarchi, A. (2020). *Fundamentals of international aviation law and policy*. Abingdon, UK: Routledge.

[135] Scott, J. (2004). Documents, types of. In: M. Lewis-Beck, A.E. Bryman. & T. Futing Liao (Eds.), *The SAGE encyclopedia of social science research methods* (pp. 281-284). Thousand Oaks, CA: SAGE Publications.

[136] Scott, J. (2014). *A dictionary of sociology* (4th ed.). Oxford, UK: Oxford University Press.

[137] Scott, J., & Marshall, G. (2009). *A dictionary of sociology* (3rd ed.). Oxford, UK: Oxford University Press.

[138] Shaw, S. (2016). *Airline marketing and management* (7th ed). Abingdon, UK: Routledge.

[139] Singapore Airlines. (2021). Sustainability Report 2020/21. Retrieved from https://www.singaporeair.com/saar5/pdf/Investor-Relations/Annual-Report/sustainabilityreport2021.pdf.

[140] Singh J, Sharma-Kumar, S., & Srivastava R. (2018). Managing fuel efficiency in the aviation sector: Challenges, accomplishments and opportunities. *FIIB Business Review*, 7(4), 244-251. https://doi.org/10.1177%2F2319714518814073Skrifvars, M., & Åkesson, D. (2016). Recycling of thermoset composites. In M.J. Taherzadeh & T. Richards (Eds.), *Resource recovery to approach zero municipal waste* (pp. 249-260). Boca Raton, FL: CRC Press.

[141] Stake, R.E. (1995). *The art of case study research*. Thousand Oaks, CA: SAGE Publications.

[142] Stake, R.E. (2005). Qualitative case studies. In N.K. Denzin & Y.S. Lincoln (Eds.), *The SAGE handbook of qualitative research* (pp. 443-466). Thousand Oaks, CA: SAGE Publications.

[143] Staples, M.D., Malina, R., Suresh, P., Hileman, J.I., & Barrett, S.R.H. (2014). Aviation CO_2 emissions reductions from the use of alternative jet fuels. *Energy Policy*, 114, 342-354. https://doi.org/10.1016/j.enpol.2017.12.007

[144] Su, Y., Zhang, P., & Su, Y. (2015). An overview of biofuels policies and industrialization in the major biofuel producing countries. *Renewable and Sustainable Energy Reviews*, 50, 991-1003. https://doi.org/10.1016/j.rser.2015.04.032

[145] Taiwo, A.M. (2011). Composting as a sustainable waste management technique in developing countries. *Journal of Environmental Science and Technology*, 4(2), 93-102.

[146] Tarczay, K., Nagy, E., & Kis-Kovács, G. (2011). Energy production, industrial processes, and waste management. In L. Haszpra (Ed.), *Atmospheric greenhouse gases: The Hungarian perspective* (pp. 367-386). Dordrecht, The Netherlands: Springer Science+Business Media.

[147] Tavares Kennedy, H. (2019). Finnair introduces CO_2 offsetting and biofuel service for customers. Retrieved from https://www.biofuelsdigest.com/bdigest/2019/01/19/finnair-introduces-co2-offsetting-and-biofuel-service-for-customers/.

[148] Taylor, I. (2020). Finnair to axe inflight sales amid pledge 'to banish' carbon. Retrieved from http://www.travelweekly.co.uk/articles/361270/finnair-to-axe-inflight-sales-amid-pledge-to-banish-carbon.

[149] Taylor, J., & Young, S. (1975). *Passenger aircraft and airlines*. London, UK: Marshall Cavendish Publications.

[150] Testa, E., Giammusso, C., Bruno, M., & Maggiore, P. (2014). Analysis of environmental benefits resulting from the use of hydrogen technology in handling operations at airports. *Clean Technologies and Environmental Policy*, 16(5), 875-890. https://doi.org/10.1007/s10098-013-0678-3

[151] Thompson, B. (2007). Ground handling opportunities for airports. *Journal of Airport Management*, 1(4), 393-397.

[152] United Nations. (2021). Sustainable development goals. Retrieved from https://sustainabledevelopment.un.org/?menu=1300.

[153] van Schoor, B. (2017). *Fighting corruption collectively: How successful are sector-specific coordinated governance initiatives in curbing corruption*. Wiesbaden, Germany: Springer.

[154] Vasigh, B., Fleming, K., & Humphreys, B. (2015). *Foundations of airline finance: Methodology and practice* (2nd ed.). Abingdon, UK: Routledge.

[155] Vásquez, L., Iriarte, A., Almeida, M., & Villalobos, P. (2015). Evaluation of greenhouse gas emissions and proposals for their reduction at a university campus in Chile. *Journal of Cleaner Production*, 108(Part A), 924-930. https://doi.org/10.1016/j.jclepro.2015.06.073

[156] Wiedemann, T., & Minx, J. (2007). A definition of 'carbon footprint'. In C.C. Pertsova (Ed.), *Ecological economics research trends* (pp. 1-11). New York, NY: Nova Science Publishers.

[157] Yin, R.K. (2018). *Case study research and applications* (6th ed.). Thousand Oaks: SAGE Publications.

[158] Zhang, B., Ritchie, B., & Mair, J. (2019). Is the airline trustworthy? The impact of source credibility on voluntary carbon offsetting. *Journal of Travel Research*, 58(5), 715-731. https://doi.org/10.1177%2F0047287518775781

[159] Zhang, J., Zhang, S., Wu, R., Duan. M., Zhang, D., Wu, Y., & Hao, J. (2021). The new CORSIA baseline has limited motivation to promote the green recovery of global aviation. *Environmental Pollution*, 289, 117833. https://doi.org/10.1016/j.envpol.2021.117833

[160] Zhou, T., & Zhang, J. (2020). Behavioural research on transport and energy in the context of aviation. In J. Zhang (Ed.), *Transport and energy research: A behavioral perspective* (pp. 279-294). Amsterdam, The Netherlands: Elsevier.

[161] Zou, B., Kwan, I., Hansen, M., Rutherford, D., & Kafle N. (2016). Airline fuel efficiency: Assessment methodologies and applications in the U.S. domestic airline industry. In J.D. Bitzan., J. Peoples & W.W. Wilson. (Eds.), *Airline efficiency* (pp. 317-352). Bingley, UK: Emerald Group Publishing.