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An Assessment of a Major Global Full-Service Network Airline's Waste Management: A Case Study of Korean Air

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Abstract— *Using an in-depth longitudinal research approach, this study has examined how Korean Air, a major global full-service network airline, manages its wastes in an environmentally sustainable manner. The study period was from 2007 to 2021. Korean Air has defined and implemented a "Green" Management Policy that underpins its sustainability goals. The airline's waste management is underpinned by the 3Rs Waste Management Framework. Korean Air aims to reduce wastes wherever possible. Where this is not possible then the airline aims to re-use its wastes. Wastes that are unsuitable for re-use are recycled when their characteristics are suitable for such an approach. Wastes that cannot be re-used, recycled, or incinerated are disposed to landfill. The airline's cabin wastes are disinfected and incinerated in accordance with the relevant regulations. Wastes generated by Korean Air can be broadly split into domestic waste generated from transportation services and designated or hazardous waste generated from aircraft maintenance. The case study found that there was an overall upward trend in Korean Air's annual recycled wastes from 2010 to 2019. The airline's incinerated wastes exhibited a general upward trend from 2007 to 2019. Koreans Air's annual wastes disposed to landfill displayed a general downward trend during the study period. Koreans Air's annual wastes were influenced by the reduced passenger traffic and flight operations due to the COVID-19 pandemic in 2020 and 2021. The COVID-19 pandemic has had a profound impact on the global aviation industry and has the global pandemic resulted in a downturn in passenger traffic and flight operations.*

Keywords—***Airline wastes, incinerated wastes, waste recycling, Korean Air, 3Rs Waste Management Framework.***

I. INTRODUCTION

All around the world, the environmental sustainability of air transport has been receiving greater focus in recent times due to its critical impact on climate change and on the environment (Budd, 2017; Chen, 2012; Daley, 2016; Teoh & Khoo, 2016). Environmental issues associated with the global air transport industry have grown in importance in recent years, and in response some airlines located throughout the world have been proactive to demonstrate their 'green' credentials (Mayer et al., 2012). Consequently, many airlines have now defined and implemented environmental related strategies that are designed to "green" their operations (Çabuk et al., 2019; Chan et al., 2021; Migdadi, 2020). Indeed, in recent decades, greening (ensuring the sustainable development of the global air transport system) has been viewed as a highly significant part of the agenda by almost all the industry's involved stakeholders (Janić, 2011). The key objective of the "greening" strategy is for an airline to make its operations more environmentally friendly wherever this is possible (Baxter, 2022).

Solid waste management and waste disposal is regarded as being one of the most significant issues in the environmental management of the global airline industry (Baxter, 2020; Li et al., 2003). Each year the air transport industry generates a substantial amount of comingle waste

(Blanca-Alcubilla et al., 2019). Considering this, airlines are now making a considerable effort to improve their waste management and to reduce waste generation where possible (Blanca-Alcubilla et al., 2019; Moynihan & Moynihan, 2019). Cabin waste is a particular area of concern. The International Air Transport Association (IATA), the world's peak airline association, has reported that around 5.7 million tons of cabin is generated by airlines, of which 80.5% was leftover food and beverages (Nakornkao & Mongkalig, 2022). Consequently, airlines in recent years have been paying increasing attention to the food waste issue, particularly in the cabin service sector of full-service network airlines due to the amount of food wastage and the consequent impact on the environment and economy (Yu et al., 2020). As a result, airlines have also been exploring a number of innovative solutions to reduce their cabin waste (International Air Transport Association, 2020).

In the global air transport industry, airline services are provided by low-cost carriers (LCCs), full-service network carriers (FSNCs), regional airlines, and charter/holiday airlines (Whyte & Lohmann, 2017). Korean Air was selected as the case airline as it an airline that has placed a very high focus and commitment to the sustainability of its operations. Korean Air is also a major global full-service network airline. In addition, Korean Air has adopted and implemented a "green" management policy. A key element of the company's "green" management policy is to minimize the airline's environmental load through proactive measures and improvement in the company's environmental performance (Korean Air, 2021a). The objective of this study is to examine how Korean Airlines sustainably manages its wastes. A secondary objective is to examine the role of recycling in Korean Air waste management. The study also aims to identify the various types of waste generated by Korean Air and how such wastes are handled. A final objective is to examine how the increase in passenger traffic during the study period has influenced the airline's ability to manage its wastes in an environmentally sustainable manner. The study period is from 2007 to 2021.

The remainder of the paper is organized as follows: the literature review presented in Section 2 presents the literature review which sets the context for the study's in-depth case study. The research method that underpinned the study is described in Section 3. The Korean Airlines case study is Section 4. The key findings of the study are presented in Section 5.

II. BACKGROUND

2.1. The Types of Airline Wastes

Airlines produce large volumes of waste which typically includes food and drink containers, newspapers and magazines, food waste (from offices, lounges/cafeterias), light bulbs, printer toner, paper, documents, and computer print outs. In addition to the waste generated from their administration and flight operations, many airlines generate quite large quantities of waste from handling their air cargo services. These wastes include tyres, fluids, lights bulbs, batteries, wood and wooden pallets, plastic wrapping material, green waste from lawn/garden care and landscaping, paper, and computer printouts (Baxter et al., 2018b).

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, 2022). Cleaning waste is leftover rubbish from items provided to passengers on the aircraft during their flight. These items include newspapers, paper towels, plastic bottles (United States Federal Aviation Administration, 2013), food dropped on the floor, amenity kits and plastic wrapping from blankets, pillows, and headsets. Cleaning waste also includes the contents of washroom bins and medical waste such as used syringes that have been left by passengers for subsequent disposal. Catering (galley) related waste comes from inflight meals, snacks and beverages served to passengers throughout the flight. This waste can also consist of leftover food, drinks and packaging which is placed back in the service trolleys, in static or compactor bins. Importantly, this waste can contain large volumes of liquid from unconsumed beverages and ice. (International Air Transport Association, 2022).

The type of meals served by an airline on its flights varies according to the duration of flight. As a result, the quantity and content of the generated waste stream is closely related to the length of the flight (Chandrappa & Das, 2012; El-Mobaidh et al., 2006).

Airline wastes can be categorized into in-flight wastes, ground activity-based wastes, industrial wastes, and hazardous wastes (Migdadi, 2020).

2.2. The Waste Management Hierarchy

The Organisation for Economic Development (2003) have noted that "waste refers to materials that are not prime products (that is, products produced for the market) for which the generator has no further use in terms of his/her own purposes of production, transformation, or consumption, and of which he/she wants to dispose". The waste management hierarchy ranks the various types of wastes disposal methods from the most to the least desirable (Davies, 2016; Pitt & Smith, 2003b). The waste management hierarchy therefore establishes the preferable

order in which solid waste should be managed and treated (Pires et al., 2019). The waste management hierarchy is as follows: reduce, re-use, recycle, recovery, and disposal (Figure 1) (Davies, 2016; Okan et al., 2019). For firms using the hierarchy, reducing waste should be their primary concern (Baxter et al, 2018a). In an ideal situation, waste should be avoided wherever possible. This means that in the waste management hierarchy, reducing or preventing waste should be the primary objective of the firm (Baxter & Srisaeng, 2021).

Fig.1: The Waste Management Hierarchy

The waste management hierarchy seeks to minimize the generation of wastes in the first instance. The aim of the hierarchy is for the firm to optimize the opportunities for reuse and recycling of materials, and to minimize the quantities of wastes that need to be disposed to landfill (Thomas & Hooper, 2013). According to the waste management hierarchy, re-use and recycling are the best methods of dealing with unavoidable waste (Pitt & Smith, 2003a). Re-using waste, wherever possible, is regarded as more favorable than recycling because the waste items does not require further processing prior to being used again (Güren, 2015). Reuse of wastes occurs when something that has already achieved its original function is once again used for another purpose. The recycling of wastes involves the reprocessing of used materials that would otherwise be considered as waste (Zhu et al., 2008). Recycling of wastes involves the collection, sorting, processing, and their conversion into raw materials that can be used in the production of new products (Park & Allaby 2013). Recovery relates to the recovery of energy that can be recovered from waste (Zhu et al., 2008). Wastes that are deemed as unsuitable for reuse or recycling can be incinerated to generate heat or electricity (Makarichi et al., 2018; Waters 2020; Zhu et al., 2008). Finally, disposal in landfill sites is regarded as the least desirable option in the waste management hierarchy (Manahan, 2011; Okan et al., 2019; Williams, 2013). Waste that is disposed to landfill and open dumping, is environmentally unsafe due to the emission of greenhouse gases (GHGs) that are produced from the wastes that are disposed in landfill dumps (Ahmed et al., 2020; Trabold & Nair, 2019).

2.3. The Types of Waste Disposal Methods Available to Airlines

2.3.1. Reuse of Wastes

According to the waste management hierarchy, re-use and recycling are the best methods of dealing with unavoidable waste (Baxter et al., 2018b; Pitt & Smith, 2003b). Re-using waste, wherever possible, is preferable to recycling because the waste items do not need to be processed prior to their subsequent re-use (Güren, 2015). Reuse occurs when something that has already achieved its original function is subsequently used again for another purpose (Zhu et al., 2008). Airlines could potentially reuse and repurpose materials. The reuse or repurposing of recovered materials also has the advantage of reducing the demand for new materials (International Civil Aviation Organization, 2022).

2.3.2. Recycling of Wastes.

When recycling waste, the waste fraction is utilized again to produce consumer goods or other products. Recycling produces less pollution and is viewed as being more sustainable than incineration (Morgan, 2009).

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). In conjunction with prevention and recycling measures, waste to energy (WTE) facilities can make a significant contribution to a firm reaching the goals of waste management (Brunner & Rechberger, 2015).

2.3.3. Incineration of Wastes

Firms that utilize incineration as a waste disposal method incinerate their wastes in a dedicated incinerator. Incineration is often a waste disposal method for hazardous wastes (Santoleri et al., 2000). Incineration is the flame-initiated, high temperature, air oxidization of organic matter (David Cooper, 1999). Wastes that are being disposed by incineration need to meet certain basic criteria. This is especially so for the energy content of the

waste, which is termed the lower calorific value (LCV), must be above a minimum level. Also, the specific composition of the waste is important. In addition, to operate the incineration facility on a continuous basis, a firm's waste generation must be stable throughout the year (Rand et al., 2000).

The incineration of solid waste by a firm has two particularly desirable purposes in a waste management system. Principally, it reduces the volume of waste to be that will be needed to be disposed of by sanitary landfill (Rand et al., 2000). Secondly, incineration can also be used by a firm to produce energy (Awasthi et al., 2019; Hettiarachchi & Kshourad, 2019). Notwithstanding, there is often an environmental impact associated with incineration of wastes as during the waste incineration process, there can be substantial emissions of carbon dioxide (CO_2) emissions produced (Reinhardt et al., 2008; Tarczay et al., 2011). Furthermore, there also may be smaller amounts of methane and nitrous oxide (NO_x) emissions produced (Tarczay et al., 2011).

2.3.4. Composting of Wastes

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). There are several advantages associated with the composting of rubbish: lower operational costs and composting also lessens environmental pollution. Composting also enables the beneficial use of the end products (Taiwo, 2011).

2.3.5. Wastes Disposed to Landfill

The least desirable waste disposal option is the disposal of wastes to landfill (Manahan, 2011; Muthu, 2020; Pitt & Smith, 2003a).

2.4. The 3Rs Waste Management Framework

One of the most popular approaches to waste management has been the adoption of 3Rs waste management framework, that is, reduce waste, reuse waste, and recycle waste (Manickam & Duraisamy, 2019; Pariatamby & Fauziah, 2014). The 3Rs waste management hierarchy promotes waste minimization through a reduction in the waste generated quantity, reusing post-consumer products and packages as well as recycling wastes as raw material or energy (Boonchit, 2020). In the 3Rs waste management hierarchy, reduction holds the first-place position, and this is followed by reuse, whilst the recycling is viewed as an extremely important component of a sustainable waste management system (Jadhav & Jadhav, 2020). The principal objective of the 3Rs waste management is to reduce the amount of waste that is disposed by landfill (Zhu et al., 2008). The reuse of waste by a firm means any its operations by which products or components that are not waste are used again for the same purpose for which they were first conceived (European Commission, 2019).

2.5. The Airline Waste Management Regulatory Framework

All cabin waste produced on a flight is subject to national waste management controls that limit pollution (International Air Transport Association, 2022). This is because many countries have imposed very stringent health and safety regulations in place for in-flight waste (Moynihan & Moynihan, 2019). Furthermore, many countries have gone further with their regulations, introducing restrictions on catering waste from international flights to protect their agricultural sector (in respect to animal health) (International Air Transport Association, 2022). Airline meals are also prepared using stringent hygiene and quality control standards (Jones, 2004; Sheward, 2006). The regulations often result in the incineration of all cabin waste. These wastes have limited potential for reuse and recycling by the airline (International Air Transport Association, 2022). Thus, as international flights are subject to strict Customs and biosecurity standards; these standards and regulatory requirements add a high degree of complexity as to how an international airline can handle the waste generated on their international services (Air New Zealand, 2019). In addition, governments also typically legislate the requirements for the handling of general and hazardous wastes as well (Baxter, 2020).

III. RESEARCH EMTHODOLOGY

3.1. Research Approach

This study was underpinned by an in-depth qualitative longitudinal research design (Derrington, 2019; Hassett & Paavilainen-Mäntymäki, 2013; Neale, 2018). Qualitative longitudinal research aims to expand and develop theories (Derrington, 2019). A case study enables the researcher(s) to explore complex phenomena (Remenyi et al., 2010; Taber, 2014; Yin, 2018). Case studies also enable the researcher(s) to collect rich, explanatory information that provides in-depth insights into the phenomenon under investigation (Ang, 2014).

3.2. Data Collections

The data used in the study was obtained from a range of documents, company materials available on the internet and records as sources of case evidence. Documents included the Korean Airlines annual ESG reports, and the airline's websites. An extensive search of the leading air

transport journals and magazines was also conducted in the study.

The key words used in the database searches included "Korean Air's Green Management Policy", "Korean Air's waste management framework", "Korean Air's annual wastes", "Korean Air's annual designated wastes", "Korean Air's annual incinerated wastes", "Korean Air's annual landfill disposed wastes", "Korean Air's annual recycled wastes", and "Korean Air's waste sources".

This study used secondary data. The three principles of data collection as suggested 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

The data collected for the case study was examined using document analysis. Document analysis is quite commonly used in case studies. Document analysis focuses on the information and data from formal documents and a firm's records that are collected by a researcher(s) when conducting their case study (Andrew et al., 2011; Yin, 2018). The documents gathered for the study were examined according to four key criteria: authenticity, credibility, representativeness and meaning (Scott, 2014; Scott & Marshall, 2009).

The document analysis was undertaken in six distinct phases:

- Phase 1: The first phase involved planning the types of the required documentation and ascertain their availability for the study.
- Phase 2: The data collection phase involved sourcing the documents and developing and implementing a scheme for the document management. The documents were stored in a case study database.
- Phase 3: The collected documents were examined to assess their authenticity, credibility and to identify any potential bias.
- Phase 4: The content of the collected documents was carefully examined, and the key themes and issues were identified and recorded in the case study.
- Phase 5: This phase involved the deliberation and refinement to identify any difficulties associated with the documents, reviewing sources, as well as exploring the documents content.
- Phase 6: In this final phase the analysis of the data was completed (O'Leary, 2004, p. 179).

Following the guidance of Yin (2018), the study's documents were downloaded and stored in a case study database. All the documents gathered for the study were all written in English. Each document was carefully read, and key themes were coded and recorded in the case study research framework (Baxter, 2022).

IV. RESULTS

4.1. An Overview of Korean Air

Korean Airlines was formed in June 1962 to succeed the private enterprise Korean National Airlines. The new airline was fully owned by the government. Korean National, established in 1947, operated services on domestic routes and provided services to Hong Kong and Tokyo. Its successor, Korean Airlines, commenced domestic services in 1962. New services were launched to Osaka and Fukuoka in Japan, and the Hong Kong service was restarted in 1966. The airline received its first Boeing B747 on 1 May 1973 (Green & Swanborough, 1975). In March 1969, the government of South Korea sold its controlling interest in Korean Airlines to the Hanjin Transportation Group (Chant, 1997; Oum & Yu, 2019). Korean Air now operates to points in Australia, Canada, Europe, the Far East, the Middle East, and the USA in addition to its domestic network (Chant, 1997). Korean Air is also a major air cargo carrying airline (Hertwig & Rau, 2010).

In June 2000, Korean Air joined Aeromexico, Air France, and Delta Airlines to form the global Skyteam alliance (Kalić et al., 2022; Kiraci, 2019; Wittmer & Hinnen, 2017). In 2008, Korean Air established its low-cost carrier (LCC) subsidiary Jin Air (Holloway, 2016). On 22 February 2022, the Korea Fair Trade Commission (KFTC) announced that it decided to conditionally approve a merger deal by Korean Air Lines ('Korean Air') to purchase fellow South Korea-based Asiana Airlines ('Asiana') (Lee & Chung, 2022). Seoul's Incheon International Airport is Korean Air principal hub airport (Malaval & Bénaroya, 2002).

As previously noted, Korean Air has adopted the full-service network carrier business model. 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". As of the end of 2020, Korean Air operated a total of 159 aircraft, which are deployed on 13 cities in Korea and 108 cities in 42 countries, which are located around the world (Korean Air, 2021b). Korean Air aircraft fleet is comprised of Boeing 787-9, Boeing 777-200, Boeing 777-300, Boeing 777-300ER aircraft. The airline's aircraft fleet also includes

Airbus A220-300, Airbus A330-200, and Airbus A330-300 aircraft. Korean Air also has a fleet of the Airbus A380 aircraft (Korean Air, 2022a). The Airbus A380 aircraft is the world's largest passenger aircraft (Dettmer, 2004; Marsh, 2016; Winterton & Turnbow, 2020).

Figure 1 presents Korean Air's annual enplaned passengers and the year-on-year change (%) for the period 2007 to 2021. One passenger enplanement measures the embarkation of a revenue passenger, whether originating, stop-over, connecting or returning (Holloway, 2016). Figure 1 shows the impact of the 2008/2009 global financial crisis on its annual passenger traffic, which decreased on a year-on-year basis in both 2008 and 2009 (Figure 1). The 2008 global financial crisis (GFC) adversely impacted air travel demand (Pearce, 2012; Piccioni et al, 2022; Wong et al., 2019). Air travel demand started to recover in mid-2009 (Yu, 2020), and Korean Air returned to positive growth in 2010, when its annual passenger traffic increased by 9.91% on the 2009 levels (Figure 1). Korean Air's annual passenger traffic decreased slightly in 2013 (-3.62%), 2014 (-0.55%), and 2017 (-0.29%), respectively, reflecting slightly lower levels of demand for its services in these respective years (Figure 1). Figure 1 shows that Korean Air was able to increase its passenger traffic in 2015 (+6.83%), and 2016 (+7.96%). Figure 1 shows, however, that there was a very steep decline in the airlines' enplaned passengers in 2020 (-72.57%). In 2020, Korean Air's annual passenger traffic was adversely impacted by the global COVID-19 pandemic. In 2020, the COVID-19 pandemic caused a decline in economic activity around the world (Dube et al., 2021), and the COVID-19 pandemic severely impacted the global economy (Crotti, et al., 2022). This decline in economic activity caused a severe disruption in the air travel market supply and demand chain (Dube et al., 2021). Air transportation was one of the sectors most adversely impacted by the corona-virus pandemic (Barczak et al., 2022; Karakuş et al., 2021; Remencová & Sedláčková, 2022; Sun et al., 2022). In addition, due to the global coronavirus crisis, most countries placed restrictive measures to confine the pandemia (Maria Iacus et al., 2020). Furthermore, the COVID-19 pandemic outbreaks led to many countries imposing travel restrictions (Akkucuk, 2020; Fabeil et al., 2020; Mat Dawi et al., 2021). The Korean government introduced border controls in 2020 in response to the COVID-19 pandemic (Kang et al., 2020). Figure 1 also shows that Korean Air's annual passenger traffic continued to be impacted by the COVID-19 pandemic and the related pandemic response measures in 2021, at which time the airline's annual passenger traffic decreased by 24.0% on the 2020 levels. The COVID-19 pandemic continued to have an impact on air travel demand in 2021 (Airports Council International, 2022).

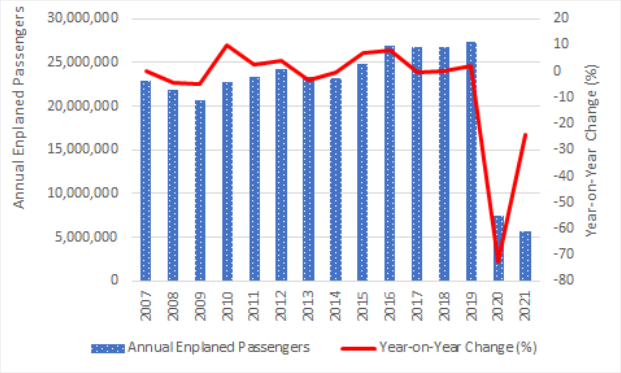

Fig. 2: Korean Airlines annual enplaned passengers and year-on-year change (%): 2007-2021

Source: Data derived from Korean Air (2007-2017, 2021b)

4.2. Korean Air Green Management Policy

Korean Air is concerned about the sustainable future of the earth and the company respects the universal values as a member of the global community. Korean Air declares that the following "Green" Management Principles will fulfill the company's social responsibilities as a leading global airline. In line with these principles, Korea Air will:

1. Improve flight procedures and introduce new aircraft to reduce noise and greenhouse gases (GHGs).
2. The company will abide by national and international environment laws and all regulations and will apply stricter internal standards.
3. The company will minimize environmental load through proactive measures and improvements in its performance.
4. The company will seek to make constant improvements in its performance to conserve resources and energy and will management them efficiently.
5. Carry out training and provide education so that the company's staff and employees clearly acknowledge environmental goals and actively join the environment protection effort.
6. The company will promote mutual cooperation with partner firms to execute green management through communication on environmental issues.
7. The company will openly share all of its green management efforts and the results to the public.

8. The company will endeavor to protect the natural environment and contribute to the development of local community through international cooperation (Korean Air, 2021a).

Korean Air has also implemented a certified ISO 14001 Environmental Management System (Korean Airlines, 2022b). ISO 14001 is a worldwide meta-standard for the implementation of an Environmental Management Systems (EMS) by an organization or business (Dentch, 2016; Grover & Grover, 2017; Heras-Saizarbitoria et al., 2011).

Korean Air has also adopted the United Nation Development Goals 3, 4, 5, 6, 8, 9,11, 13, 15 and 17 (Korean Air, 2019). 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; Saner et al., 2021; Vij & Singh, 2020).

In 2019, recognizing the environmental pollution caused by single use plastic waste, Korean Air banned the use of single use plastic cups, straws, and plastic muddlers for in-flight services and, as a result, substituted paper cups and straws that are made of environmentally certified paper (Korean Air, 2021b).

4.3. Korean Air 3Rs Waste Management Policy

Korean Air has adopted the use of the 3Rs waste management framework as part of its goal to mitigate the impact that its wastes have upon the environment.

Korean Air has made a variety of efforts to reduce the amount of cabin waste produced on its flights. In light of this goal to reduce wastes, Korean Air has changed the design of plastic cup lids and lids covering in-flight meals to reduce the amount of single-use plastics that will most probably become waste. In addition, the airline has modified the sizing and specification of disposable hand towels placed in restrooms. As a result, Korean Air has achieved the same effect as reducing pulp usage by approximately 104 tons per year. Due to COVID-19 preventive measures, Korean Air still needs to use disposable products, however, the airline plans to gradually replace the items currently used inside its aircraft with more eco-friendly (biodegradable plastics, paper products, and so forth) products in order to reduce the amount of cabin waste from its flights (Korean Air, 2022c).

Korean Air has reduced the use of disposable products and now uses items that can be reused. This measure assists the airline to reduce the amount of waste generated. As part of its waste management policy, Korean Air disinfects and washes the reusable passenger seat covers when cleaning the interior of its aircraft. Furthermore, eco-friendly headrest covers are presently only used on domestic flights and small-sized aircraft, but the airline plans to use them on its international services after diversifying the type of materials used (Korean Air, 2022c).

Korean Air has implemented new methods to increase the recycling rate of its aircraft cabin waste. To help achieve this, Korean Air has held campaigns and training sessions to improve its cabin crew's awareness on recycling. Korean Air aims to recycle and separately collect each type of waste. In addition, the airline has also recently designed recycling bags that will be used for the separate collection of trash. These recycling bags are anticipated to contribute to an increased recycling rate of aircraft cabin waste (Korean Air, 2022c).

It is important to note that various functions are performed during the time that that an aircraft spends on the ground in between flights (Ashford et al., 2013; Kazda & Caves, 2015; Thompson, 2007). As part of its goal to mitigate the impact of its operations on the environment, Korean Air aims to minimize the impact that its aircraft ground handling operations has on the environment. Korean Air has replaced the plastic wraps used to prevent the luggage and air cargo consignments from getting damaged with an eco-friendly renewable vinyl. Up to 50% of the materials used to make the renewable vinyl are reused, including waste vinyl. Koren Air has been able to replace the 350 tons of vinyl used annually for its operations with the more environmentally friendly vinyl (Korean Air, 2022c).

4.4. Korean Air Waste Sources

Korean Air wastes are produced from the airlines passenger services (flights), air cargo services, maintenance of ground service equipment (GSE), in-flight meal production, and from their aircraft maintenance (Korean Air, 2009). Korean Air's onboard aircraft wastes include waste from the aircraft cabin services, for example, newspapers, magazines, and plastic bottles. These wastes are separated and recycled. The airline's catering waste is the leftover waste from its in-flight services (these wastes are incinerated). General waste is comprised wastes from offices and airport operations, these wastes are sorted and recycled. Korean Air also has industrial wastes which include oil and fuel waste from aircraft maintenance works (these wastes are subject to commissioned treatment) (Korean Air, 2007). Wastes generated by Korean Air can be broadly split into domestic waste generated from transportation services and designated waste generated from aircraft maintenance. All food waste originating from the airline's in-flight service is incinerated in accordance with the regulations prescribed by the Animal and Plant

Quarantine Agency (Korean Air, 2021b). The in-flight food waste is disinfected prior to its incineration Designated or hazardous wastes produced by Korean Air, include waste oil, waste paint, and waste organic solvents. These wastes are produced during the aircraft maintenance and manufacturing processes (Korean Air, 2020).

4.5. Korean Air Total Annual Wastes

Korean Air's total annual wastes and the associated year-on-year change for the period 2007 to 2021 is presented in Figure 3. As can be observed in Figure 3, there are three discernible trends with the airline's annual wastes during the study period. There was a general downward trend in this metric in the early years of the study, that is, from 2007 to 2009. Korean Air's annual wastes decreased by 4.46% in 2009, and by 6.01% in 2009. As noted previously, the airline's operations and its passenger traffic were adversely impacted by the global financial crisis (GFC) in both 2008 and 2009, and this had a concomitant impact on the airline's annual wastes in both these years. Figure 3 shows that there was a general upward trend in the airline's annual wastes from 2010 to 2018. This general upward trend is demonstrated by the year-on-year percentage change line graph, which is more positive than negative, that is, all the values are above the line. Figure 3 shows that there was a spike in this metric in 2010, when the airline's annual wastes increased by 9.04% on the 2009 levels. This increase in wastes was in line with the airline's passenger growth rate in 2010, at which time it increased its passenger traffic by 9.91%. Figure 3 shows that there was a further spike in the airline's annual wastes in 2016, at which time they increased by 5.60% on the 2015 levels. In 2016, Korean Air's passenger traffic increased by 7.96%, and this increase in passenger traffic could have influenced the amount of additional waste handled by the airline in 2016. Figure 3 shows that there was a small annual decrease in the airline's wastes in 2019, at which time they decreased by 0.23% on the 2018 levels. This was a favorable outcome as Korean Air was able to accommodate additional passenger traffic, whilst at the same time reducing the quantity of its wastes. There was a very significant annual decrease in Korean Air's annual wastes in 2020, at which time they decreased by 58.53% on the 2019 levels (Figure 3). This significant decrease could be attributed to the very significant decrease in passengers and flights because of the COVID-19 pandemic in 2020. Figure 3 shows that there was a further very significant decrease in the airline's wastes in 2021, at which time they decreased by 45.22% on the 2021 levels. As previously noted, Korean Air's annual passenger traffic and its flight operation were still impacted by the COVID-19 pandemic in 2021, and this led to the sharp drop in its annual wastes in 2021.

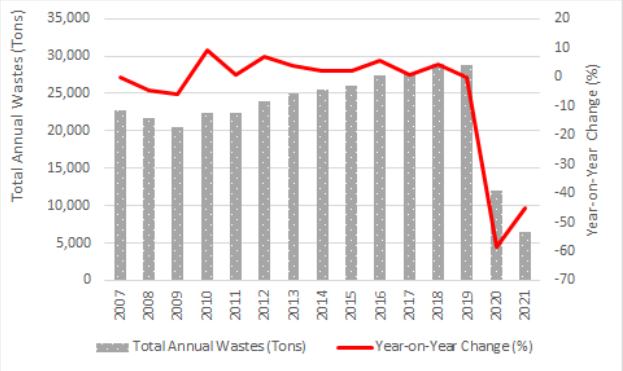

Fig. 3: Korean Airlines total annual wastes (all sources) and year-on-year change (%): 2007-2021

Source: Data derived from Korean Air (2007-2014, 2017, 2021, 2022c)

4.6. Korean Air Annual Designated Wastes

In South Korea, hazardous waste is always defined as designated wastes, and such wastes are controlled under the *Solid Waste Management Act* (Jian, 2012). According to El-Din M. Saleh (2016, p. 4), "hazardous wastes are classified as hazardous if they exhibit one or more of ignitability, corrosivity, reactivity, or toxicity". At an airport, hazardous wastes are produced from aircraft refueling, aircraft operations, aircraft, and ground service equipment (GSE) maintenance and equipment and facilities cleaning. Major aircraft overhauls also use toxic chemicals to remove paint, and these wastes pose an environmental threat (Culberson, 2011). Other contaminants that are produced at an airport's operations or activities include detergent formulations, solids, oils, greases, residues, solvent residues, and heavy metals (Grantham, 1996). As noted earlier, designated wastes produced by Korean Air, include waste oil, waste paint, and waste organic solvents. These wastes are produced during the aircraft maintenance and manufacturing processes (Korean Air, 2020).

Korean Air's annual designated wastes and the year-on-year change (%) for the period 2014 to 2021 is depicted in Figure 4. Figure 4 shows that there were two discernible trends in this metric during the study period. From 2014 to 2018, there was a general upwards trend. This upward trend is demonstrated by the year-on-year percentage change line graph, which is more positive than negative, that is, all the values are above the line. During this period, there were two quite significant annual increases in Korean Air's annual designated wastes. These increases were recorded in 2015 (+28.07%), and 2018 (+21.07%), respectively (Figure 4). These increases could be attributed to a higher level of maintenance activities performed by the airline in both 2015 and 2018, respectively. Figure 4

shows that there were two significant annual decreases in this metric during the latter years of the study, that is, 2018 to 2021. These annual decreases were recorded in 2018 (-18.21%), and 2021 (-45.39%), respectively (Figure 4). These decreases are favorable for Korean Air, as they help to mitigate the possible environmental impact associated with the disposal of hazardous materials. In 2020, the airline's annual designated wastes increased by 28.96% on the 2019 levels, reflecting the greater use of hazardous chemicals in its maintenance activities in 2020 (Figure 4). In 2021, the airline's annual designated wastes decreased by 45.39% on the 2020 levels (Figure 4). This decrease could be attributed to a lower requirement for hazardous materials by the airline in 2021.

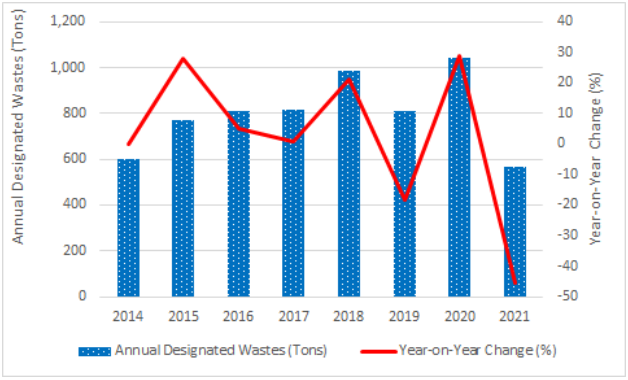

Fig. 4: Korean Airlines total annual designated wastes and year-on-year change (%): 2014-2021

Note: Data prior to 2014 is not available

Source: Data derived from Korean Air (2014, 2017,2021, 2022c)

4.7. Korean Air Annual General Wastes

Korean Air's annual general wastes and the year-on-year change (%) for the period 2014 to 2021 is depicted in Figure 5. Figure 5 shows that Korean Air's annual general wastes displayed a general upward trend from 2014 to 2019, when they increased from 23,825 tons in 2014 to a high of 28,013 tons in 2010. Once again, this general upward trend is demonstrated by the year-on-year percentage change line graph, which is more positive than negative, that is, all bar one value is above the line. During this period, the most significant annual increase in the airline's general wastes occurred in 2016 (+6.34%) (Figure 5). In 2016, Korean Air's annual passenger traffic increased by 7.96%, and this had an impact on the airline's general wastes in 2016 (Figure 5). This was because there were higher amounts of wastes generated due to the increase in passenger traffic and flights operated. There was a slightly smaller annual increase in the airline's general wastes in 2018, at which time they increased by 3.91% on the 2017 levels (Figure 5). This increase could be attributed to the slightly higher levels of passenger traffic in 2018, as well as slightly different waste patterns in 2018. During the study period, there were three years where Korean Air's annual general wastes decreased on a year-on-year basis. These annual decreases were recorded in 2017 (-4.09%), 2020 (-61.05%), and 2021 (-45.21%), respectively (Figure 5). In 2017, Korean Air's annual passenger traffic decreased by 0.29%, and this could have led to smaller volumes of general wastes. The decrease of 4.09% was a favorable outcome for the airline as it was able to reduce its annual general wastes at a higher rate than the reduction in passenger traffic. The annual decreases in the airline's general wastes in both 2020 and 2021, reflect the lower levels of passenger traffic and services because of the COVID-19 pandemic. In 2020, the airline's passenger traffic decreased by 72.57%, and this contributed to the lower volumes of general wastes in that year. In 2021, the airline's passenger traffic decreased by 24.0%, and this also led to the lower volumes of general wastes in 2021. In 2021, the airline was able to reduce its annual general wastes at a substantially higher rate than the decrease in passenger traffic, which was a very favorable outcome as it enabled the airline to help mitigate the possible impact that wastes could have upon the environment.

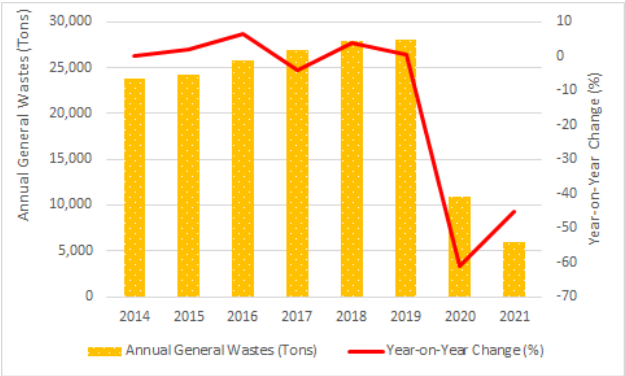

Fig. 5: Korean Airlines total annual general wastes and year-on-year change (%): 2014-2021

Note: Data prior to 2014 is not available

Source: Data derived from Korean Air (2014, 2017,2021, 2022c)

4.8. Korean Air Annual Incinerated Wastes

Korean Air's annual incinerated wastes and the associated year-on-year change (%) for the period 2007 to 2021 is presented in Figure 6. As can be observed in Figure 6, there was a general upward trend in the airline's annual incinerated wastes during the period 2007 to 2018. Figure 6 shows that the airline's annual incinerated wastes increased from 11,060 tons in 2007 to a high of 18,429 tons in 2019. This general upward trend can therefore be

demonstrated by the year-on-year percentage change line graph, which is more positive than negative, that is, all bar one value is above the line. Figure 6 shows that the three most significant annual increases in this metric, occurred in 2012 (+9.19%), 2016 (+9.73%), and 2018 (+7.93%), respectively. The reason for these annual increases in the incineration of wastes can be attributed to the growth in the airline's annual passenger traffic, as all cabin wastes are required to be incinerated. Also, in 2012, 2016, and 2019, the airline's incinerated wastes increased at a higher rate than its passenger growth, so this suggests that the airline also handled wastes that were deemed appropriate for incineration in these respective years. Figure 6 shows that in the latter years of the study period, that is, from 2019 to 2021, Korean Air's annual incinerated wastes decreased on a year-on-year basis. The two most significant annual decreases in this metric were recorded in 2020 (-71.82%), and 2021 (-61.54%), respectively (Figure 6). The annual decrease in 2020 was almost in-line with the decrease in passenger traffic, which declined by 72.57% on the 2019 levels. In 2021, the airline's passenger traffic decreased by 24.0%, which meant that there were lower volumes of aircraft cabin waste that requited disposal by incineration. Also, in 2021, Korean Air increased its use of incineration as the types of wastes handled were deemed to be appropriate for incineration. The incineration of wastes is an important part of Korean Air's waste management. Importantly, incineration offers many advantages for an organization, such as, an airline, and these include waste volume reduction, detoxification, regulatory compliance, environmental impact mitigation, particularly for organic materials that would leach from landfills and would emit odors, and energy recovery (Santoleri et al., 2000). Other advantages of waste incineration are there is little risk of groundwater contamination, which is a disadvantage of landfill wastes, and the residue ash from incineration takes up less space when it is disposed to landfill, this is because the incineration (burning) process greatly reduces the volumes of many wastes (Travis & Crystal Cook, 1989). Furthermore, bottom ash and Air Pollution Control (APC) residues are new sources of secondary metals (Brunner & Rechberger, 2015).

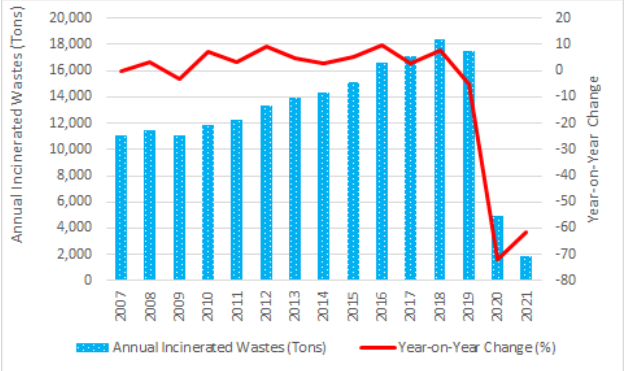

Fig. 6: Korean Airlines annual incinerated wastes and year-on-year change (%): 2007-2021

Source: Data derived from Korean Air (2007-2014, 2017, 2021, 2022c)

An important waste management efficiency measure used in the airport industry is the proportion of wastes that are incinerated (Baxter et al., 2018a). This metric can be very usefully applied in the airline industry. Korean Airlines annual incinerated wastes as a share of total annual wastes and year-on-year change (%) for the period 2007 to 2021 is depicted in Figure 7. Figure 7 shows that Korean Airlines annual incinerated wastes as a share of total annual wastes has oscillated throughout the study period. The most significant increase in this metric was recorded in 2008, at which time it increased by 8.09% on the 2007 levels. In 2008, Korean Air's annual landfill disposed wastes and its recycled wastes decreased on a year-on-year basis, whilst in contrast the airline's incinerated wastes increased by 3.28%. As a result of these factors, Korean Air's annual incinerated wastes increased as a share of its total annual wastes in 2008. The second most significant annual increase in this metric occurred in 2016, when it increased by 3.90% on the 2015 levels. In 2016, incinerated wastes increased at a higher rate than the airline's recycled wastes, whilst landfill disposed wastes decreased on a year-on-year basis in 2016. Consequently, the airline's incinerated wastes accounted for a higher share of total wastes in 2016. Figure 7 also shows that during the study period, there were four years where this metric decreased on an annualized basis. These annual decreases occurred in 2010 (-1.72%), 2019 (-5.09%), 2020 (-32.07%), and 2021 (-29.79%), respectively (Figure 7). In 2010, the airline's annual incinerated and landfill disposed wastes declined, whilst in contrast its recycled wastes increased on a year-on-year basis. Consequently, the airline's annual incinerated wastes declined as a share of its total annual wastes in 2010. A similar situation occurred in 2019 when the airline's recycled wastes increased, yet at the same time both its incinerated and landfill wastes decreased on a year-on-year basis. So, once again, the airline's annual incinerated wastes declined as a

share of its total annual wastes in 2019. In both 2021, and 2021, Korean Air's recycled wastes decreased at a lower rate than that of its incinerated and landfill disposed wastes, and this resulted in incinerated wastes accounting for a lower share of the airline's total annual wastes in both 2020 and 2021.

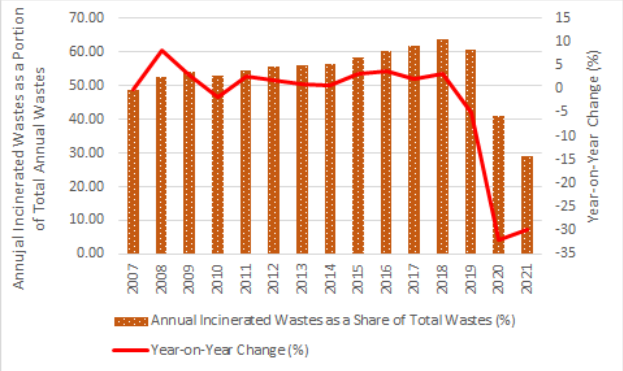

Fig. 7: Korean Airlines annual incinerated wastes as a share of total annual wastes and year-on-year change (%): 2007-2021

Source: Data derived from Korean Air (2007-2014, 2017, 2021, 2022c)

4.9. Korean Air Annual Landfill Disposed Wastes

Korean Airlines annual wastes disposed to landfill and the year-on-year change (%) for the period 2007 to 2021 is depicted in Figure 8. As can be observed in Figure 8, Korean Airlines annual landfill disposed wastes have exhibited an overall downward trend, decreasing from a high of 1,305 tons in 2007 to a low of 11 tons in 2021 (Figure 8). This general downward trend is demonstrated by the year-on-year percentage change line graph, which is more negative than positive, that is, more values are below the line than above. Figure 8 shows that there was a significant annual increase in the airline's landfill disposed wastes in 2017, at which time they increased by 35.58% on the 2016 levels. This increase could be attributed to some of the types of wastes that were produced by Korean Air in 2017 were not suitable for either recycling or incineration, and hence, there was an increased requirement to dispose of such wastes to landfill. Figure 8 also shows that there was a further spike in the airline's landfill disposed wastes in 2012, when they increased by 16.80% on the 2011 levels. Once again, this increase could be attributed to some of the types of wastes produced in 2012 not being suitable for either recycling or incineration. Figure 8 also reveals that there were eight years during the study period where Korean Air was able to significantly reduce its annual landfill disposed wastes. These annual decreases were recorded in 2009 (-26.75%), 2010 (-19.04%), 2013 (-26.23%), 2015 (-23.67%), 2016 (-31.22%), 2019 (-65.56%), 2020 (-70.05%), and 2021 (-78.0%), respectively (Figure 8). The annual decreases in this metric in 2009 and 2010 could be attributed to the declines in the airline's passenger traffic and services due to the global financial crisis (GFC). In 2013, Korean Air was able to increase its recycling and incineration of its wastes whilst also decreasing the requirement to dispose wastes to landfill. In 2015, there were differing patterns in Korean Air's wastes with both landfill and recycled wastes declining, whilst in contrast, the airline was able to incinerate more wastes in 2015. In 2016, Korean Air was once again able to increase the recycling and incineration of its wastes whilst also decreasing the requirement to dispose its wastes to landfill. In 2019, there were once again differing patterns in Korean Air's wastes with both landfill and incinerated wastes declining, whilst in contrast, the airline was able to recycle more wastes in 2019. As previously noted, Korean Air, like other airlines, was severely impacted by the COVID-19 pandemic and the related pandemic response measures, and this had a concomitant impact on its annual landfill disposed wastes in 2020 and 2021. This was because the scale of the airline's operations and its passenger traffic were considerably lower because of the COVID-19 pandemic. Figure 8 also shows that Korean Air's landfill wastes account for the smallest share of its overall wastes. As noted earlier, the disposal of wastes to landfill is regarded as the least preferable method of waste disposal. Wastes that are disposed by landfilling and open dumping is regarded as being environmentally unsafe. This is because of the emission of greenhouse gases (GHGs) produced from the disposed wastes (Ahmed et al., 2020; Trabold & Nair, 2019). Thus, the strategy of Korean Air to minimize its landfill disposed wastes helps the airline to mitigate its environmental footprint.

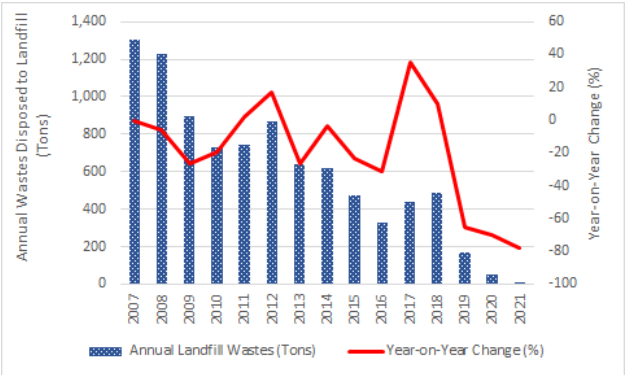

Fig. 8: Korean Airlines annual wastes disposed to landfill and year-on-year change (%): 2007-2021

Source: Data derived from Korean Air (2007-2014, 2017, 2021, 2022c)

Another important waste management efficiency measure used in the airport industry is the proportion of wastes

disposed to landfill (Baxter et al., 2018a; Graham, 2005). Once again, this metric can be very usefully applied in the context of the airline industry. Korean Airlines annual landfill disposed wastes as a share of total annual wastes and year-on-year change (%) from 2007 to 2021 is presented in Figure 9. Figure 9 shows that Korean Airlines annual landfill disposed wastes as a share of total annual wastes has largely displayed an overall downward trend throughout the study period. Figure 9 shows that Korean Airlines annual landfill disposed wastes as a share of total annual wastes declined from a high of 5.73% in 2007 to a low of 0.17% in 2021 This general downward trend can also be demonstrated by the year-on-year percentage change line graph, which is more negative than positive, that is, more values are below the line than above. Figure 9 shows that there were seven years during the study period, where this metric decreased very significantly on an annualized basis. In 2009, Korean Air's annual landfill disposed wastes as a share of total wastes decreased by 22.02% on the 2008 levels (Figure 9). In 2009, the airline's landfill disposed wastes decreased on a year-on-year basis, whilst its incinerated and recycled increased in the same year. Thus, as a result, Korean Air's landfill wastes accounted for a lower share of its total wastes in 2009. The same situation occurred in 2010, when once again Korean Air's landfill disposed wastes as a share of total wastes declined by 25.74%, whilst its recycled and incinerated wastes both increased as a share of the airline's annual wastes in 2010 (Figure 9). In 2015, Korean Air's annual landfill disposed wastes as a share of total wastes decreased by 25.40% on the 2014 levels (Figure 9). The reason for this decrease in this metric in 2015 was due to the higher incinerated waste volumes, the slightly lower recycled wastes, and the significant decrease in landfill wastes in 2015. Because of the variations in the Korean Air's annual wastes in 2015, its landfill disposed wastes accounted for a smaller share of its total wastes. The most significant annual decrease in Korean Air's annual landfill disposed wastes as a share of total wastes occurred in 2019, when this metric decreased by 65.47% on the 2018 levels (Figure 9). In 2019, Korean Air's annual landfill wastes decreased as did its incinerated wastes. In contrast, the airline's recycled wastes increased in 2019. Consequently, in 2019, Korean Air's landfill disposed wastes accounted for a smaller share of the airline's total annual wastes. This large decrease in this metric in 2019, was followed by a further two annual decreases in this metric in both 2020 and 2021. In 2020, Korean Air's landfill disposed wastes as a share of total wastes declined by 27.58% on the 2019 levels (Figure 9). In 2020, the airline's landfill disposed wastes decreased at a higher rate than its incinerated and recycled wastes, and this led to the annual decrease in this metric in 2020. The same situation applied in 2021, when Korean Air's annual landfill wastes as a share of total wastes decreased by 59.52% (Figure 9). In 2021, the airline's landfill disposed wastes decreased at a higher rate than its incinerated and recycled wastes, and this led to the annual decrease in this metric in 2021.

Figure 9 shows that there was a significant spike in this metric in 2017, at which time it increased by 34.45% on the 2016 levels. As previously noted, Korean Air's annual landfill disposed wastes grew at a higher rate than its incinerated wastes in 2017, whilst its recycled wastes decreased on an annualized basis in the same year. As a result, the airline's landfill disposed wastes accounted for a higher share of its total annual wastes in 2017. Figure 9 also shows that there was another annual spike in this metric in 2012, at which time it increased by 9.36% on the 2011 levels. In 2012, the airline's annual landfill disposed wastes grew at a higher rate than its incinerated and recycled wastes, and, as a result, the airline's landfill wastes accounted for a higher share of its total annual wastes in 2012.

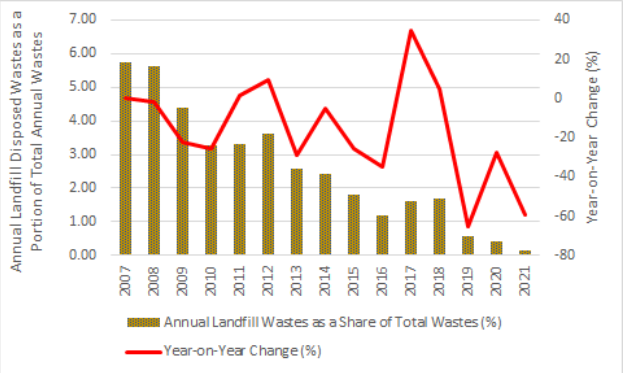

Fig. 9: Korean Airlines annual landfill disposed wastes as a share of total annual wastes and year-on-year change (%): 2007-2021

Source: Data derived from Korean Air (2007- 2014, 2017, 2021, 2022c)

4.10. Korean Air Annual Recycled Wastes

Prior to examining Korean Air's annual recycled wastes, it is important to note that re-use and recycling are two of the key elements in the airline's waste management policy. Paper, wood, cans, and PET bottles are separated and recycled by the airline (Korean Air, 2021b). Korean Air is also recycling plastic waste instead of disposing of it by landfill or incineration. The plastic waste generated in the aircraft cabin service is used as solid fuel through a sorting process, or as a pellet material for construction (Korean Air, 2020). Korean Airlines annual recycled wastes and year-on-year change (%) for the period 2007 to 2021 are depicted in Figure 10. Figure 10 shows that there were

three discernible trends in Korean Air's annual recycled wastes. During the early years of the study, that is, 2007 to 2009, there was a downward trend in Korean Air's annual recycled wastes. In 2008, the airline's annual recycled waste decreased by 12.58% on the 2007 levels (Figure 10). A similar situation occurred in 2009, when the airline's annual recycled wastes declined by 6.56% on the 2008 levels. As noted earlier, Korean Air's annual passenger traffic and its level of operations was adversely impacted by the 2008/2009 global financial crisis, and this led to a reduction in its wastes, including its recycled wastes in both 2008 and 2009. Figure 10 shows that there was an overall upward trend in Korean Air's annual recycled wastes from 2010 to 2019. This overall upward trend is demonstrated by the year-on-year percentage change line graph, which is more positive than negative, that is, more values are above the line than below. Figure 10 shows that there was a pronounced spike in the airline's annual recycled wastes in 2010, at which time they increased by 14.43% on the 2009 levels. In 2010, a higher share of Korean Air's wastes was suitable for recycling, and this enabled the airline to manage these wastes through their recycling system. A similar situation occurred in 2019, when the airline's recycled wastes increased by 12.36% (Figure 10). Like in 2010, Korean Air was able to increase its recycling of wastes in 2019, which was a favorable outcome for the airline. During the period 2010 to 2019, the most significant annual decrease in Korean Air's annual recycled wastes, was recorded in 2017, at which time they decreased by 3.81% on the 2016 levels (Figure 10). In 2017, the types of wastes generated by Korean Air were more suitable for incineration (+2.85%) and disposal to landfill (+35.58%) and these waste characteristics led to the slight decrease in recycled wastes in 2017. Figure 10 shows that there were very significant decreases in Korean Air's annual recycled wastes in both 2020 and 2021. In 2020, Korean Air's annual recycled wastes decreased by 37.64% on the 2019 levels. This decrease could be attributed to the impact of the COVID-19 pandemic and the related pandemic response measures had on Korean Air's passenger traffic and operations. Because of the lower levels of passenger demand and flight operations, Korean Air was able to reduce its wastes in 2020. In 2021, Korean Air's annual recycled wastes decreased by 33.51% on the 2020 levels (Figure 10). Korean Air was still affected by the ongoing COVID-19 pandemic in 2021, and once again, this resulted in the airline producing smaller amounts of recycled wastes in 2021.

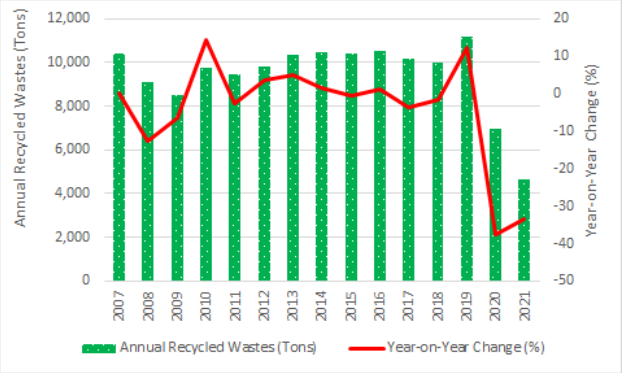

Fig. 10: Korean Airlines annual recycled wastes and year-on-year change (%): 2007-2021

Source: Data derived from Korean Air (2007-2014, 2017, 2021, 2022c)

Another important waste management efficiency measure used in the airport industry is the proportion of wastes that are recycled (Baxter et al., 2018a; Graham, 2005). Once again, this metric can be very usefully applied in assessing the waste management efficiency of an airline. Korean Airlines annual recycled wastes as a share of the airline's total annual wastes and the year-on-year change (%) for the period 2007 to 2021 is presented in Figure 11. Figure 11 shows that there was a slight overall downward in this metric during the period 2007 to 2018. The two most significant annual decreases in this metric were recorded in 2008 (-8.39%), and 2018 (-5.88%) (Figure 11). In 2008, Korean Air's annual recycled wastes decreased on a year-on-year basis, whilst its incinerated wastes increased in the same year. Also, in 2008, landfill wastes also decreased, but at a lower rate than those of the airline's recycled wastes. As a result of these variations in Korean Air's waste mix in 2008, recycled wastes accounted for a smaller share of the airline's total annual wastes. In 2018, Korean Air's annual recycled wastes declined on a year-on-year basis, whilst at the same time, the airline's incinerated and landfill disposed wastes increased, and this resulted in its recycled wastes accounting for a smaller share of its total annual wastes in 2018. Figure 11 shows that there were five years in the study period where Korean Air's annual recycled wastes as a share of its total wastes increased on an annualized basis. These annual increases occurred in 2010 (+4.94%), 2013 (+1.17%), 2019 (+12.59%), 2020 (+50.38%), and 2021 (+21.36%), respectively (Figure 11). In 2010, Korean Air's annual recycled wastes grew at a higher rate than its incinerated wastes whilst its landfill wastes declined by 19.04%. As a result of these factors, the airline was able to increase its recycled wastes as a share of its total annual wastes. The same situation applied in 2013, when the airline's recycled

wastes increased at a slightly higher rate than its incinerated wastes and, in the same year, its landfill wastes declined on a year-on-year basis. Consequently, the airline was able to increase its recycled wastes once again as a share of its total annual wastes. In 2019, Korean Air increased its recycled wastes and at the same time it decreased the quantity of wastes that were to be disposed through either incineration or by landfill. This variation in the waste mix enabled Korean Air to increase its recycled wastes once again as a share of its total annual wastes in 2019. As previously noted, Korean Air's annual wastes declined in both 2020 and 2021 due to the impact of the COVID-19 pandemic. In both 2020 and 2021, the airline's annual recycled wastes decreased at a lower rate than its incinerated and landfill wastes, and this led to recycled wastes accounting for a higher share of its total annual wastes in both 2020 and 2021.

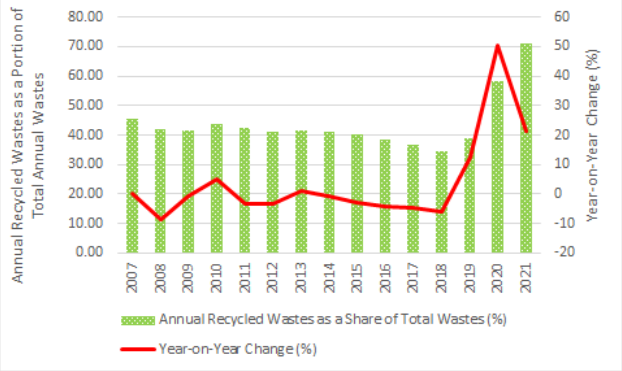

Fig. 11: Korean Airlines annual recycled wastes as a share of total annual wastes and year-on-year change (%): 2007-2021

Source: Data derived from Korean Air (2007-2014, 2017, 2021, 2022c)

V. CONCLUSION

This study has examined how Korean Air, a major global full-service network airline, sustainably manages its wastes. The study was underpinned by an in-depth longitudinal research design. The data collected for the study was examined by document analysis. The study period was from 2007 to 2021.

Korean Air has defined and implemented a comprehensive "green" management policy that underpins it goal of managing its operations and activities in an environmentally sustainable manner. The case study revealed that Korean Air has adopted the use of the 3Rs Waste Management Framework, and, as a result, the airline aims to reduce its wastes in the first instance. A key waste management strategy of the airline is to re-use wastes wherever this practicable. Wastes that are not suitable for re-use are recycled wherever the waste characteristics make this possible. Korean Air's aircraft cabin wastes are disinfected and subsequently incinerated in accordance with the appropriate regulatory framework. The final waste management method is the disposal of wastes that are unsuitable for re-use, recycling, or incineration to landfill.

The case study revealed that Korean Air's wastes are heterogenous in nature. Korean Air wastes are produced from the airlines passenger services (flights), air cargo services, maintenance of ground service equipment (GSE), in-flight meal production, and from their aircraft maintenance. Korean Air's onboard aircraft wastes include waste from the aircraft cabin services, for example, newspapers, magazines, and plastic bottles. General waste is comprised of wastes from offices and airport operations, these wastes are sorted and recycled. Korean Air also has industrial wastes which include oil and fuel waste from aircraft maintenance works. Wastes generated by Korean Air can be broadly split into domestic waste generated from transportation services and designated waste generated from aircraft maintenance. The in-flight food waste is disinfected prior to its incineration Designated or hazardous wastes produced by Korean Air, include waste oil, waste paint, and waste organic solvents. These wastes are produced during the aircraft maintenance and manufacturing processes.

The case study highlighted the importance that Korean Air places on the recycling of wastes. The case study found that there was an overall upward trend in Korean Air's annual recycled wastes from 2010 to 2019. During 2020 and 2021, Korean Air, like other airlines, was adversely impacted by the COVID-19 pandemic and the related pandemic response measures. The reduction in passenger traffic and flight operations resulted in reduced waste volumes. However, in both 2020 and 2021, the airline's recycled wastes decreased on an annualized basis at a lower rate than its incineration and its landfill disposed wastes, reflecting the importance that Korean Air places on recycling wastes.

Korean Air's annual passenger traffic grew from 22,850,000 passengers in 2007 to 27,351,000 passengers in 2019. In 2021, the airline carried 5,700,000 passengers. Like other airlines, Korean Air, was adversely impacted by the COVID-19 pandemic which has had a very adverse impact on airline passenger demand. The case study found that there were three discernible trends with the airline's annual wastes during the study period. There was a general downward trend in the airline's annual wastes in the early years of the study, that is, 2007 to 2009. This downward trend was followed by a general upward trend in the airline's annual wastes from 2010 to 2018. The case study also revealed that there were very significant annual

decreases in Korean Air's annual wastes in both 2020 and 2021. These significant decreases in the airline's wastes in 2020 and 2021 could be attributed to the very significant decrease in passenger traffic and the airline's flight operations because of the COVID-19 pandemic in both 2020 and 2021.

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