


EREM 77/4 Journal of Environmental Research, Engineering and Management Vol. 77 / No. 4 / 2021 pp. 73–85 DOI 10.5755/j01.erem.77.4.29574	Environmentally Sustainable Airline Waste Management: The Case of Finnair PLC	
	Received 2021/08	Accepted after revision 2021/10
	 http://dx.doi.org/10.5755/j01.erem.77.4.29574	

Environmentally Sustainable Airline Waste Management: The Case of Finnair PLC

Glenn Baxter*, Panarat Srisaeng

School of Tourism and Hospitality Management, Suan Dusit University, Huahin Prachaup Khiri Khan, Thailand, 77110

Graham Wild

School of Engineering and Information Technology, University of New South Wales, Canberra, ACT, Australia, 2612

*Corresponding author: g_glennbax@dusit.ac.th

Airlines around the world are increasingly focusing on the environmentally sustainable management of wastes produced as a by-product of their operations. The objective of this work was to analyze Finnair's non-hazardous waste (NHW) types and quantities, their NHW management strategies, and the methods used to mitigate the environmental impact of their NHW, over the period 2008 to 2019. To achieve these objectives, the study was underpinned by an in-depth mixed methods research design; this incorporated a quantitative longitudinal study and a qualitative document analysis. The results revealed that despite significant growth of their operations, Finnair's annual NHWs have declined over the study period. Finnair's annual NHWs decreased from 5,710 tonnes in 2008 to 4,212.01 tonnes in 2019. The primary waste disposal methods used by the airline are waste-to-energy recovery and waste recycling, both in-house and by external third-party service providers. Smaller quantities of wastes are composted. Since 2015, the company has had a policy of not disposing wastes to landfill.

Keywords: aviation, recycling, sustainability, transport, waste management.

Introduction

Globally, the air transport industry is a crucial driver of economic growth, world trade, and tourism (Air Transport Action Group, 2019). The air transport industry value chain is comprised of many key stakeholders, which include airlines, airports, aircraft manufacturers and tour agents (Baxter et al., 2018a). The transportation of passengers and air cargo are the key services provided by airlines. However, in the provision of their air transportation services airlines generate substantial amounts of commingled waste (Blanca-Alcubilla et al., 2019). Management of solid wastes and their disposal are significant issues for sustainability management of the world airline industry (Baxter, 2020). As a result, airlines are investing considerable time and efforts into improving their waste management practices, specifically, trying to reduce waste production wherever possible (Blanca-Alcubilla et al., 2019).

The objective of sustainable waste management is a multi-tiered approach based on several “r’s”; these include waste reduction, waste re-use, waste recycling, and energy recovery (Soltani et al., 2016). The principles of sustainable waste management cut across industries and apply in the aviation context to airports (Baxter et al., 2018b), as well as airlines. An example of an airline that has implemented these approaches to sustainable waste management is Finnair. Finnair is Finland’s national flag carrier in addition to being the country’s largest airline. Finnair has typically placed an extremely strong emphasis on sustainability and environmental management, with a significant emphasis on sustainable waste management. In addition, Finnair has set an objective to be among the leading airlines in the sustainable development of the global aviation sector (Finnair, 2020). Like many companies, Finnair has both hazardous and non-hazardous wastes. This study exclusively focused on the airline’s non-hazardous waste (NHW) as these account for the most significant quantities of the airline’s annual wastes. The objective of this paper was to qualitatively analyze Finnair’s NHW management strategies, and to quantitatively analyze the annual quantities of NHW generated by the airline. The

observed quantitative trends were then explained with a qualitative assessment of the mitigation strategies utilized to reduce the environmental impact of the airline. The study covers the period from 2008 to 2019.

Background

Airlines produce waste from direct activities equivalent to other corporate settings, producing “e-waste, recycling waste, construction waste, solid waste, organic waste, packaging waste, paper waste, plastic waste, food waste, dry waste,” etc. (Sambhanthan and Potdar, 2016). As part of a service industry transporting people for extended periods of time, airlines also produce waste directly from customers/passengers. These wastes are referred to as deplaned aircraft waste (Baxter et al., 2018a); they “include bottles and cans, newspaper and mixed paper, plastic cups and service ware, food waste, food soiled paper, as well as paper towels.” In addition to corporate offices and headquarters, airlines will also operate satellite offices in various airports at various times around the globe. These on airport activities including interfaces with passengers (lounges, etc.) also produce waste similar to the previously identified direct and indirect wastes. All these situations produce additional waste through cleaning and other support services which are typically contracted out to external organizations. That is, both office and aircraft cleaning activities produce various wastes.

Airlines, as other industries, have several waste disposal options. These include composting, recycling, incineration, and disposing to landfill. Composting waste refers to the process in which the organic parts of solid wastes are converted into a useful biomaterial. This inert material can be utilized as fertilizers for plants, as a soil conditioner, and as a general landfill cover (Harper, 2004, p. 3). There are several advantages associated with the composting of rubbish: these are the lower operational costs, lessened environmental pollution, and use of the end products (Taiwo, 2011). With incineration the firm’s waste fraction is

incinerated in a dedicated incineration facility. In sustainable waste management, the incineration of solid wastes can be useful in two ways (Fulekar, 2010). The first of these is to reduce the quantity of wastes sent to landfill, by reducing complex structures and materials to those found after burning (Rand et al., 2000). Furthermore, wastes can be incinerated as fuel in a conventional power plant for electricity generation, or in a cogeneration plant for electricity and heat generation (Rahman et al., 2017). However, there is often an environmental impact associated with incineration of waste; that is, during waste incineration there are substantial emissions of carbon dioxide (CO₂) (Tarczay et al., 2011). There may also be smaller amounts of methane and nitrous oxide (NO_x) emissions (Tarczay et al., 2011). When managing waste, disposal to sanitary landfill sites is the least desirable waste management option (Pitt and Smith, 2003); this is because the use of landfill is considered as an environmentally unfriendly act, given that landfills also produce greenhouse gas emissions (GHGs) (Trabold and Nair, 2019). The circular economy is a modern approach to business in which the “end-of-life” concept is replaced with reducing, reusing, recycling, and waste recovery, such that a new cycle of materials, products, or infrastructure utilize the wastes of the prior cycle (Andersen, 2007). The classic example of this is the aluminum used in beverage cans, and the fact that 75% of all aluminum ever produced is still in use today (McCormick, 2018). The circular economy implies that there will be less quantities of waste produced and discarded from both manufacturing and raw materials processes (Ginga et al., 2020). The circular economy goes well beyond simple recycling; it is founded a “restorative industrial system” that focuses on the treatment of waste as a resource (Ghosh, 2020). The tradition approach involves the short linear life cycle from production to disposal, the so called “take-make-consume-dispose” system. This is exemplified by the simple incandescent light globe, and the planned obsolescence with the Phoebus cartel limiting the product life to only 1000 hours (Krajewski, 2014). In contrast, the circular economy seeks to improve resource efficiency, involve resource recovery, and the re-use of as much material as possible, ideally 100% (Kubule

et al., 2019). The circular economy has three principal activities: 1) to reduce the use of non-renewable unsustainable raw materials, 2) to re-use previously processed materials, and 3) to recycle waste into new materials in other processes or industries (Burneo et al., 2020). In some cases, there is a fourth circular economy activity, that of product redesign (Burneo et al., 2020; Kyriakopoulos et al., 2019). For a company/business/organization to achieve the benefits of a circular economy approach, the following steps need to be undertaken: reuse, recycling, recovery, and waste prevention (Kyriakopoulos et al., 2019). Furthermore, the adoption of a circular economy enables organizations to improve the value adding of products and processes through the avoidance of waste (Ghinea and Gavrilescu, 2019).

Research Method

The research design utilized in this work was a mixed methods approach (Creswell and Plano-Clark, 2017), specifically, an exploratory design (Hair, 2011). In this exploratory design, a qualitative methodology was initially undertaken, followed by a quantitative methodology. The qualitative methodology utilized was “a qualitative longitudinal case study” (Neale, 2018), while the quantitative methodology was descriptive research based on correlation (Leedy and Ormrod, 2015).

The data used in this research were taken from corporate documents and materials, all readily available online. Key documents included annual reports, as well as sustainability reports. Further online searches utilized the terms “Finnair sustainable waste management policy”, “Finnair annual non-hazardous wastes”, “Finnair’s composted wastes”, “Finnair’s wastes-to-energy recovery wastes”, “Finnair’s recycled wastes”, and “Finnair’s wastes disposed to landfill”. All collected documents represent secondary data, as reported; that is, no primary data about the waste quantities and strategies was directly observed, measured, or collected. As recommended by Yin (2018), three principles of data collection were applied: 1) utilizing multiple sources of case evidence, 2) the use of a case study database for data

management, and 3) the documentation of a chain of evidence. All qualitative data that were collected for the case study were assessed with document analysis. In this approach, data and information from the corporate records and formal documents were the basis of the case study (Yin, 2018). Following the guidance of Scott (2014), four key criteria were applied when examining the documents collected: "1) authenticity, 2) credibility, 3) representativeness, and 4) meaning". The documents were all in English, and each was carefully examined, and key themes were coded and recorded and were included in the discussion of the case study (Baxter, 2019).

For the quantitative data analysis, the correlation between the various waste metrics were examined to determine if any were statistically significant with respect to time. While time is not the cause of any change, initiative and strategies occur over time changing the waste quantities. All waste types included in this study were non-hazardous with hazardous waste quantities being excluded. These NHWs included composted, recycled, incinerated (for energy recovery), landfill, and reutilized (total minus landfill). As well as the annual trends in the NHWs, these quantities were also measured relative to the enplaned passenger (PAX) and revenue passenger kilometer (RPK). As part of the assessment of the statistical significance of the correlations, the Student t test was utilized for the inference (Heiman, 2011). The associated statistical hypotheses can then be stated as:

Null hypothesis (H_0): $r = 0$

Alternative hypothesis (H_{A1}): $r > 0$, or

Alternative hypothesis (H_{A2}): $r < 0$

Here, r is the correlation coefficient. If there is no correlation, such that there is no association with time, then r will be 0. The two alternative hypotheses are utilized as the qualitative strategies should be implemented with a specific goal, to improve something (increase the metric over time, so $r > 0$), or to reduce something ($r < 0$). This then means that for all the statistical tests, only a one-sided t test was utilized. Given the use of a one-sided test and the relatively short timeframe of the available data, the confidence level was increased to 99%, or an alpha value of 0.01. The dataset covers 12 years, which then for correlation

(with 2 dimensions) leaves 10 degrees of freedom. The corresponding critical value is therefore 3.17. If a measured t statistic is greater than the critical value, it means that the associated correlation is statistically significant.

Results and Discussion

Finnair case study

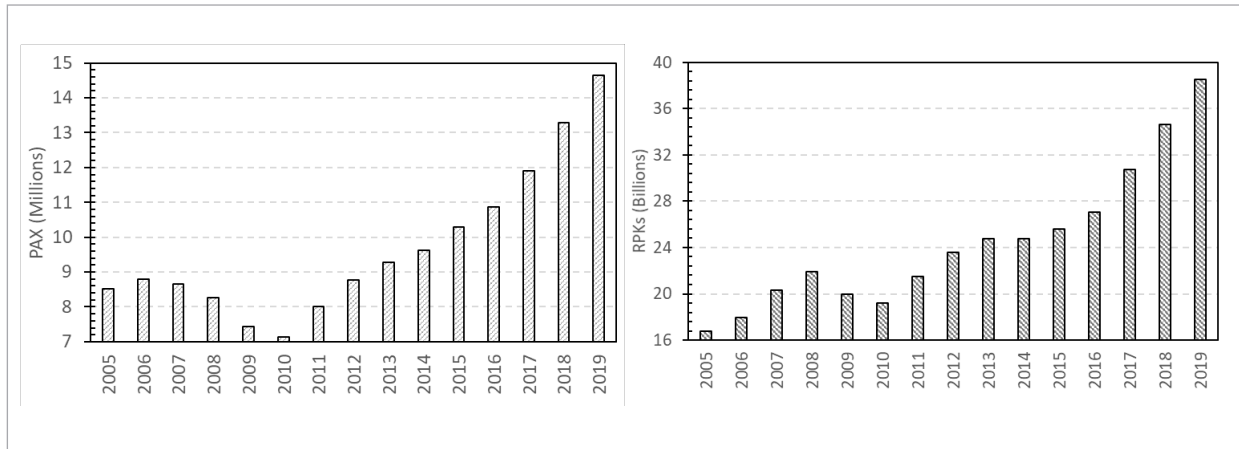
Finnair is one of the oldest serving airlines, with its origins dating back to 1 November 1923, when private interests established a new airline called Aero O/Y. Commercial services commenced on 20 March 1924 when the new airline began a service from Reval in Estonia. Shortly thereafter Aero O/Y introduced a Helsinki-Stockholm service via Turku. This service was started in conjunction with ABA Airlines of Sweden (Chant, 1997). Aero O/Y operated exclusively with seaplanes prior to the opening of Finland's first airports in 1936 (Taylor and Young, 1975). In the post World War II period, Aero O/Y operated its services with a fleet of ex-military Douglas DC3 aircraft. Also, around this time, the airline launched services to other European countries. The Finnish Government began purchasing shares 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 when the company was seeking to establish a more distinctive, nationalistic image (Brimson, 1985). In September 1999, Finnair became a member of the major global airline alliance Oneworld (Hayward, 2020). Today, Finnair is a full-service network carrier (FSNC) that specializes in both passenger and air cargo transportation. Through its Aurinkomatkat-Suntours (later Aurinkomatkat) and Finnair Holidays brands, Finnair also offers package tours in addition to its passenger and air cargo services. At the time of the current study, the Finnair aircraft fleet comprised 83 aircraft, which included 16 state-of-the art Airbus A350-900XWB aircraft (Finnair, 2021a).

Fig. 1 presents Finnair's total annual passengers (PAX) and revenue passenger kilometers (RPKs) from 2005 to 2019. RPKs represent the work unit of

passenger transport, being determined by the product of the number of passengers carried and the distance travelled. For reference a PAX is defined as the number of embarkations, which can include originating passengers, stop-over passenger, connecting passengers, or returning passengers (Holloway, 2016).

Finnair's total annual PAX and RPKs grew from 7.4 million PAX and 21.8 billion RPKs in 2008 to 14.6 million PAX and 38.53 billion RPKs in 2019. As seen in Fig. 1, following a small decrease in PAX in 2010 there has been a steady increase in RPKs and PAX numbers from 2011 to 2019.

Fig. 1. Finnair's annual PAX (left) and RPKs (right) 2005–2019. Source: Finnair (2021b)



Finnair waste analysis

Finnair's total annual wastes and the year-on-year changes (%) from 2008 to 2019 are presented in Fig. 2. Fig. 2 shows that the highest annual quantity of waste was recorded in 2008 (5,710 tonnes), whilst the lowest quantities of waste were recorded in 2015 (3,615.2 tonnes). The highest single increase in waste was in 2013, when the quantity of wastes increased by 19.93% on the 2012 value. The largest single annual decrease in the quantity of wastes was recorded in 2012, when total annual wastes decreased by 16.62% on the previous year's value. During 2010, Finnair's total annual wastes decreased by 4.46%. This decrease was due to the results of a waste reduction program, greater attention paid to waste processing, and a decline in the number of flights operated by the airline during 2010 (Finnair, 2011). The significant decrease in waste quantities in 2012 (19.93%) was due to the aircraft fleet and route network optimization and downsizing of operations by the company. In addition, Finnair also placed a greater focus on waste sorting in 2012 (Finnair, 2013). During 2013, the large increase

in wastes (19.92%) could primarily be attributed to the increase in the number of flights operated by Finnair (Finnair, 2014). The second largest decrease in Finnair's annual wastes occurred in 2014, when total wastes decreased by 15.12%. This decrease was due to the reductions in operations within Finnair Technical Services, combined with divestments of business operation of the airline's subsidiary, Finncatering Oy (Finnair, 2015). As can be observed in Fig. 2, Finnair's total annual wastes increased in 2016 (+6.83%), 2017 (+6.37%), and 2018 (+9.67%), respectively. These annual increases in wastes were due to the growth in traffic carried by Finnair (Finnair, 2021b). Also illustrated in Fig. 2 is the breakdown of the total waste by the corresponding disposal method. These will each be discussed in more detail. The most noticeable trend is the reduction to almost zero of waste disposed of to landfill, and the growth of waste incinerated for energy generation.

Throughout the study period, Finnair has utilized the composting of suitable wastes as part of its sustainable waste management strategies. Fig. 3 (left)

presents the airline's annual composted wastes and the year-on-year change (%) from 2008 to 2019. As can be seen, the annual composted wastes increased over the period 2008 to 2010 and then reduced significantly after 2013. The largest quantity of composted wastes was recorded in 2010 (469 tonnes), whilst the lowest annual quantity of composted wastes was recorded in 2019 (13.3 tonnes).

The largest single annual increase in composted wastes was recorded in 2010 (+30.6%), whilst the single largest annual decrease occurred in 2019 (-79.7%). The decrease in the quantity of composted wastes was due to the airline's policy of applying circular economy principles in its business operations, as well as reducing the quantity of waste generated by the company (Finnair, 2020).

Fig. 2. Finnair's total annual wastes in Gg (or kilotonnes) and the year-on-year change (%) 2008–2019 (left) and the corresponding breakdown by disposal method (right). Source: Finnair (2021b)

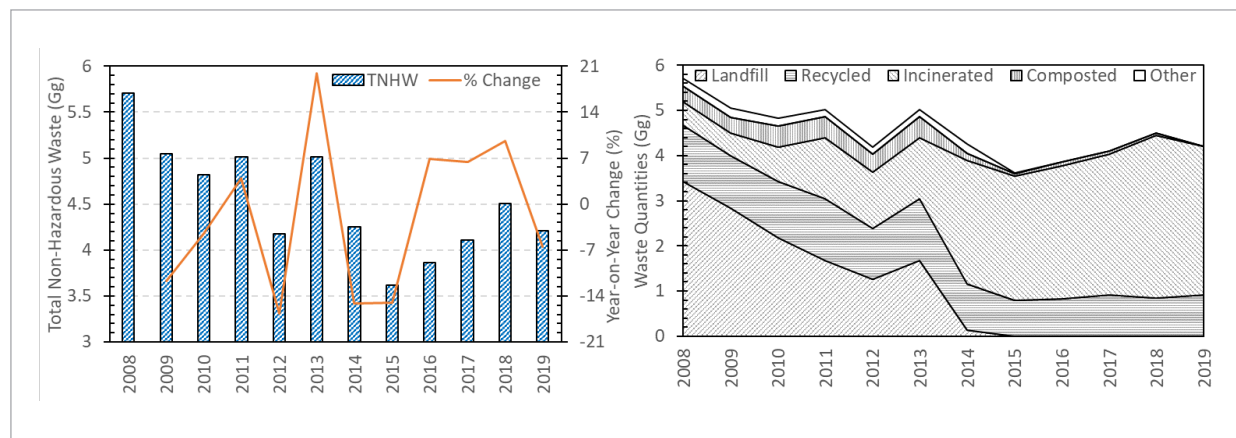
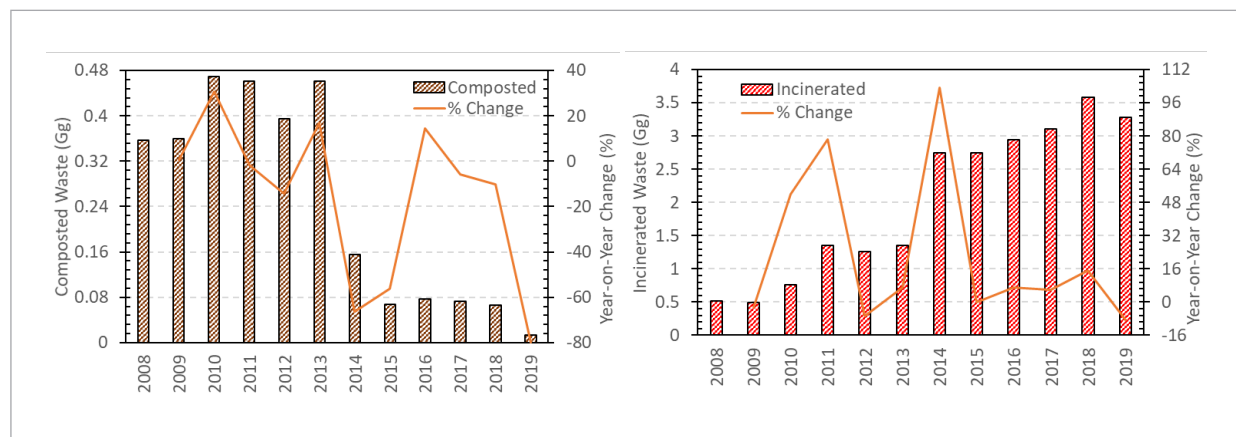


Fig. 3. Finnair's total annual composted (left) and incinerated (right) wastes and the year-on-year change (%) 2008–2019. Source: Finnair (2021b)



The annual quantities of Finnair's energy recovery wastes together with the year-on-year changes (%) for the period 2008 to 2019 are also presented in Fig. 3 (right). As can be observed, Finnair's annual energy

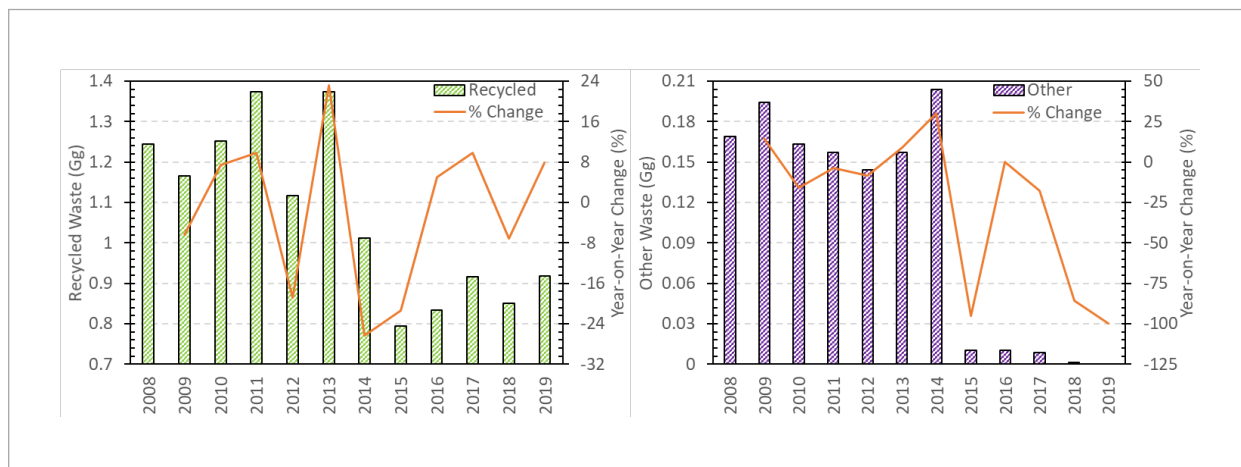
recovery wastes have predominantly exhibited an upward trend. That is, the majority of the year-on-year percentage change line graph data points are positive. The annual energy recoverable wastes increased from

a low of 512 tonnes in 2008 to a high of 3,587.8 tonnes in 2018. The second highest quantity of energy recoverable wastes was recorded in 2019 (3,281.5 tonnes). The largest single increase in the annual energy recoverable wastes occurred in 2014, when the annual energy recoverable wastes increased by 103.33%. The largest single annual decline in energy recoverable wastes occurred in 2019, when there was a decline of 8.53% on the previous year levels.

The annual recycled wastes handled inhouse by Finnair and the year-on-year change (%) from 2008 to 2019 are presented in Fig. 4 (left). As can be observed, Finnair's annual recycled wastes have fluctuated quite noticeably over the study period. The highest annual

quantity of recyclable wastes occurred in 2011 (1,374 tonnes) and 2013 (1,374 tonnes), whilst the lowest quantity of recyclable wastes occurred in 2015 (794.9 tonnes). The largest single annual increase in the airline's recyclable wastes was recorded in 2013 when the recyclable wastes increased by 23.11%. The largest single decrease in recyclable wastes occurred in 2014, when the recyclable wastes decreased by 26.34% on the 2013 levels. This was followed by a further decrease of 21.45% in 2015. Despite the fluctuations in the annual quantities of recyclable wastes throughout the study period, recycling of wastes is still an important sustainable waste management strategy for Finnair.

Fig. 4. Finnair's total annual recycled (left) and other (right) wastes and the year-on-year change (%) 2008–2019. Source: Finnair (2021b)



Finnair also has other wastes, which are processed by a service provider(s) and subsequently reutilized. Finnair's annual other wastes and the year-on-year change (%) from 2008 to 2019 are depicted in Fig. 4 (right). This shows that the annual quantities of other recyclable wastes have largely exhibited a strong downward trend from a high of 204.0 tonnes in 2014 to zero quantities in 2019. The largest single annual increase in such wastes occurred in 2014, when there was a 29.93% increase on the previous year levels. The other waste data also show that there were three years in the study period where there was a significant decrease in these wastes. These decreases occurred in 2015 (-95%), 2018 (-85.71%), and 2019 (-100%).

The annual wastes disposed to landfill by Finnair and the year-on-year change (%) from 2008 to 2019 are depicted in Fig. 5 (left). As a general policy, waste produced by Finnair's operations is no longer disposed of in landfills. The effects of this policy are clearly illustrated in the year-on-year percentage change line graph, where almost all of the data points are negative. Indeed, the data show that there has been a strong downward trend in the wastes disposed to landfill from a high of 3,427 tonnes to zero annual quantities in the period 2015 to 2017 and 2019. In 2018, however, there was a very small quantity (300 kg) disposed to landfill. The data show that the wastes disposed by landfill increased by 32.19% in 2013, which was the

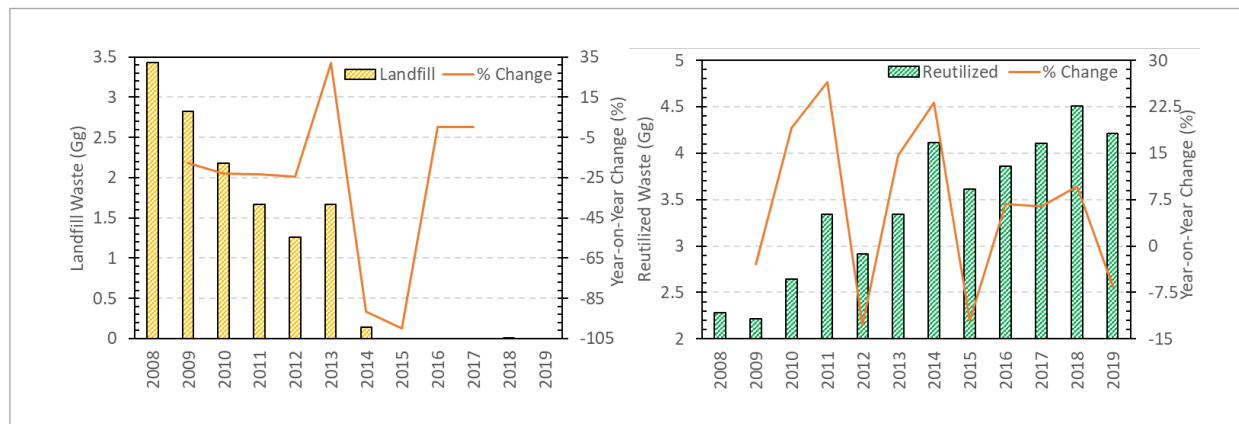
most significant annual increase reported throughout the study period. The largest single annual decrease in wastes disposed by landfill was recorded in 2015, when wastes disposed to landfill decreased by 100%. The difference between the total waste and the landfill waste in the reutilized waste is also shown in Fig. 5 (right).

Statistical analysis

Table 1 includes all the statistical testing results from the 23 regression tests completed. These 23 regression tests are made up of the 5 different waste categories (composted, incinerated, recycled, other and landfill) relative to the four key waste efficiency

measures (annual quantity, per PAX, per RPK, and as a percentage of total wastes). The total waste is the remaining 3 cases, as annual quantity, waste per PAX, and the waste per RPK. The table gives values for the correlation coefficients (r) and the corresponding t value, with the gradient (m) included to indicate the direction (positive or negative) and magnitude of the correlation. Specifically, m gives the quantified change in the corresponding metric per year. For reference, the critical value to compare the t values to is 3.17 at the 99% confidence level. Given the short duration of the data set, this high level of significance was selected to ensure that the observed results were valid and reliable.

Fig. 5. Finnair's total annual landfill (left) and reutilized (right) wastes and the year-on-year change (%) 2008–2019. Source: Finnair (2021b)



The annual waste per passenger is an especially useful environmental indicator (Graham, 2005) and is a convenient measure of waste efficiency (Janić, 2007). The metric is preferred to be as low as possible and to decrease with higher levels of output over a given time-period (typically a year) (Janić, 2007). In Table 1, Finnair's total annual wastes, the total annual wastes per PAX, and the total annual wastes per RPK from 2008 to 2019 all had strong negative correlations. The annual quantity of waste per PAX decreased from a high of 77.2 kilograms in 2008 to a low of 28.8 kilograms in 2019. This is a very favorable trend given the large increase in the growth of passengers carried by the airline over the study period. Furthermore, during

the study period, there have been times when the airline has recorded growth in PAX whilst at the same time decreasing its annual waste quantities. For example, in 2019, passenger traffic grew by 9.77%, yet the annual waste decreased by 6.52%. This suggests that Finnair can grow its passenger traffic whilst at the same time the company is able to sustainably manage its waste quantities, and hence, mitigate the environmental impact associated with the wastes generated.

Finnair's composted wastes, composted wastes per passenger, and the total annual wastes per revenue passenger kilometer, and percentage of total wastes from 2008 to 2019 were considered. As with the total

Table 1. Correlation testing results of the waste categories for the various measures. All results are statistically significant at the 99% confidence level. Legend: T = Total, C = Composted, E = Energy generation, R = Recycled, O = Other reutilized, L = Landfill disposed

Disposal	Metric	Units	m	r	t
T	Raw	Gg	-0.121	-0.724	10.5
	/PAX	kg	-0.041	-0.962	35.2
	/RPK	g	-0.015	-0.969	39.0
C	Total	Gg	-0.043	-0.847	15.9
	%	%	-0.008	-0.810	13.8
	/PAX	kg	-0.006	-0.870	17.7
E	Total	Gg	0.310	0.963	35.5
	%	%	0.078	0.944	28.7
	/PAX	kg	0.020	0.861	16.9
R	Total	Gg	-0.045	-0.765	11.9
	%	%	-0.004	-0.512	6.0
	/PAX	kg	-0.011	-0.914	22.5
O	Total	Gg	-0.020	-0.847	15.9
	%	%	-0.004	-0.780	12.5
	/PAX	kg	-0.003	-0.893	19.9
L	Total	Gg	-0.322	-0.928	24.9
	%	%	-0.062	-0.936	26.6
	/PAX	kg	-0.041	-0.929	25.0
L	Total	Gg	-0.015	-0.928	25.0
	/PAX	kg	-0.041	-0.929	25.0
	/RPK	g	-0.015	-0.928	25.0

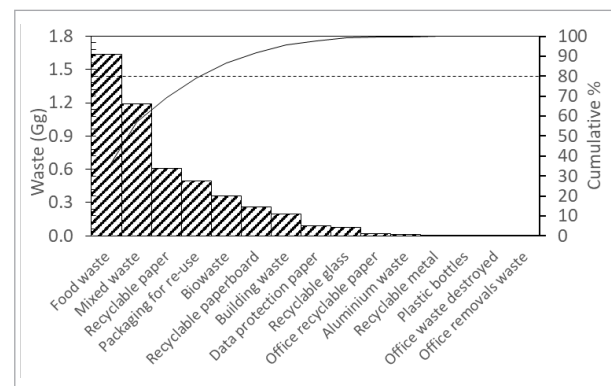
waste metrics, all the composted waste metrics have strong correlations. These are also negative, which for composting may appear to be an issue; however, the waste reduction strategies implemented by Finnair have clearly resulted in a reduction of a large proportion of wastes that were traditionally composted. Conversely, all the metrics for energy recoverable wastes have a strong positive correlation. Part of the increase to energy recoverable wastes has clearly come from wastes that were previously composted. The same is true for recycled wastes, where similarly strong negative correlations are observed for all the metrics, and for all three recycled waste measures (inhouse,

other, and combined). Again, the negative correlations for recycling imply less recycling; however, there is a clear strategy to utilize waste where possible for energy generation. Finally, landfill wastes have a similar correlation, with all metrics strongly negative. Looking at the raw numbers from 2008, 3.4 Gg was sent to landfill, 1.4 Gg was recycled, 0.5 Gg was used for energy generation, and 0.35 Gg was composted. In 2019, composted and landfill wastes were negligible, while 0.9 Gg was recycled, while 3.25 Gg was used for energy generation. This shows that Finnair has been able to offset all wastes previously sent to landfill, utilizing them for energy generation, while in general also reducing the total quantities of wastes. Looking at the m values, we note that the environmentally friendly wastes (composted and recycled) have reduced at a lower rate (-0.043 Gg/yr and -0.045 Gg/yr, respectively) relative to the total wastes (-0.12 Gg/yr), while the environmentally unfriendly waste (landfill) has reduced at a greater rate (-0.32 Gg/yr) than the total wastes. These indicators show that the waste management strategies are resulting in positive outcomes.

Waste composition

Fig. 6 shows the typical composition of Finnair’s annual wastes, excluding hazardous wastes. The majority of the waste can be seen to be food waste, mixed waste, recyclable paper, and packaging for re-use (for energy generation). Given the need for food associated with airline passengers, it is not surprising that food waste is the alone accounts for 33% of the total annual waste.

Fig. 6. Pareto plot of Finnair’s waste composition. Source: Finnair (2021b)



Waste reduction strategies

As part of its environmental management and sustainability policy, Finnair has introduced the circular economy principles across all its business operations, with the goal of increasing waste recovery, cost efficiency, and safety. Finnair also plans to reduce the quantity of waste generated. As a commencing point the airline has prescribed long-term targets aiming for in-flight catering sustainability. There have been ongoing actions directed at achieving this objective with some of the first definitive changes being 1) a reduction in the individually plastic packaged milk portions, 2) the introduction of cardboard packaging for hot meals replacing the traditional CPET (Crystalline Polyethylene Terephthalate, safe for cooking), 3) a reduction in plastic amenity kits, and 4) a redesign of the packaging associated with onboard duty-free sales selection (the Nordic Kitchen Brand). At the time of the current study, these changes had resulted in the reduction of 80.0 tonnes of wastes annually. In addition, recycled materials as part of its service design, for example, salad containers and business class slippers, are being made from recycled PET (Finnair, 2020).

As a result of regulations and contagious animal health concerns, some parts of Finnair's waste chains are considered unsafe for recycling or biogas production. The in-flight wastes arriving at Helsinki Airport are reused (Finnair, 2020); this can be in the form of electricity or heat generation, for biogas production, or as manure or other material for repurposing. Importantly, no waste from Finnair at Helsinki airport is disposed to landfill (Finnair, 2020). As previously noted, the disposal of waste to landfill is viewed as being the least preferable method in sustainable waste management (Manzoor et al., 2020).

In 2014, Ekokem Oy Ab was chosen as the new waste management partner for Finnair. At the same time, Finnair established the new waste management objectives that included further waste recovery efforts, greater cost efficiencies, and increases in safety, while reducing the overall waste quantity generated. In practical terms, this means that since 2014 waste utilization for energy or as other materials has greatly increased. Importantly, simplified waste handling with mixed waste and energy waste combined has been

facilitated by Ekokem's power plants in Riihimäki, Finland, which utilizes thermal waste processes. Furthermore, European Union (EU) by-products Regulation which covers food wastes that originate from outside of the EU now enable these to be thermally processed. This enables these wastes to be utilized with other waste to generate electricity or for heat co-generation (Finnair, 2015).

Finnair has a set a target to eliminate at least half of all single-use plastics out of the business by the end of 2022. This target will enable the airline to reduce its annual plastic waste by 230 tonnes. As an example, the airline is replacing the current plastic cutlery utilized with economy class meals with more environmentally friendly options. This measure alone will result in a further reduction of 53 tonnes of plastic wastes from inflight services each year. Finnair also plans to reduce its food waste by 50% by the end of 2022 (Green Air, 2020).

The objectives of Finland's waste policies have been to promote sustainability when it comes to the use of natural resources, in addition to ensuring that any wastes produced do not present a danger to human health or result in harmful consequences for the environment. In Finland, wastes can only be disposed of in sanitary landfills if the wastes recovery is neither financially nor technically feasible. Under Finland's Waste Policy, if reusing is not possible, then the waste must be principally recycled as raw materials for other purposes, which can be for energy generation (Ministry of the Environment, 2021). Thus, as noted in the case study, Finnair aims to recycle wastes wherever possible as well as recover other wastes as energy.

Conclusions

The primary objective of this work was to analyze Finnair's non-hazardous waste management strategies. The effect of these strategies was then quantified by looking for statistically significant correlations in the annual quantities of non-hazardous waste generated by the airline. In order to achieve this objective, the study utilized an in-depth longitudinal case study research design that included both qualitative and quantitative

analysis. The single company case study was carefully selected based on international standing and commitment to the environmental sustainability of operations by an airline, and the ready availability of data. As a result, Finnair was selected as the case firm. Document analysis was used to qualitatively assess the case study data. The study covered the period from 2008 to 2019.

The case study revealed that Finnair has utilized four key waste management strategies to handle its waste in an environmentally sound manner. These waste management measures have included composting, recycling, recovery of wastes to energy, and wastes disposed to landfill. Finnair's principal waste management measure is the use of waste to energy technologies. This is followed by the recycling of wastes both in-house and by third party service providers and composting. Since 2014, no wastes have been disposed by landfill, except for a very small amount of waste (300 kg) in 2018.

Despite the strong growth in passenger traffic and route network expansion, Finnair has been able to reduce its annual non-hazardous wastes from 5,710 tonnes in 2008 to 4,212.01 tonnes in 2019. The lowest annual quantity of non-hazardous waste was recorded in 2015 (3,615.2 tonnes). The annual waste per PAX declined from a high of 77.2 kg of waste per passenger in 2008 to a low of 28.8 kg of waste per passenger in 2019. This is a very favourable outcome for Finnair which highlights that the airline has been able to successfully grow its passenger traffic base whilst at the same time reducing the quantities of waste that are necessary to deliver its service offering.

The case study revealed that the annual quantities of waste disposed by composting have declined from a high of 469 tonnes in 2010 to a low of 13.29 tonnes in 2019. Despite the decline in the annual quantities of composted wastes, there are still environmental benefits associated with this waste management measure. Throughout the study period, Finnair recycled wastes in-house and using external third-party service providers. The annual quantities of in-house recycled wastes fluctuated throughout the study period, with the highest quantities recorded in 2013 (1,374 tonnes) and the lowest annual quantities occurring in 2015 (794.91 tonnes). In 2019, the airline recycled in-house 917.23 tonnes of waste. The total annual quantities of wastes recycled by external service providers declined over the study period from a high of 194 tonnes in 2009 to a low of zero tonnes in 2019. This downward trend may be attributed to a greater in-house recycling capability and a change in the types of products that may require recycling processing by an external provider at the end of their life cycle. The case study revealed that the wastes disposed by Finnair to landfill over the study period declined from a high of 3,427 tonnes in 2008 to zero quantities in the period 2015 to 2019. The downward trend in wastes disposed by landfill could be attributed to Finnair's policy of avoiding the use of landfill as a waste disposal measure as well as the Finland Government regulation that stipulates that waste can only be disposed of in landfills if the wastes recovery is neither technically nor financially feasible.

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