

A Sectoral Study on Energy Production from Human Movement at The Airport

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Abstract

Throughout the history of civil aviation, developing technology, changing demands and needs of passengers, expectations of stakeholders, and increasing awareness about sustainability have changed the structure of airports and the opportunities they offer. Increasing awareness about sustainability has directed humanity towards non-conventional energy sources.

Human energy, which is among the non-conventional energy sources and whose source is concentrated in airport terminals, constitutes the focus of the study. The main purpose of the research is to determine the conversion methods of kinetic energy arising from passenger mobility into electrical energy at airports, to create environments in which passengers participate in energy production in terminal areas, to evaluate the perspectives of aviation professionals on post-modern energy production in the context of passenger mobility and to create the first step in raising awareness on the subject.

The data that forms the basis of the research was obtained through interviews with aviation professionals through vignettes prepared for this purpose. In the light of the literature and global current practices, two separate vignettes were created about the methods of generating electricity by pedalling a bicycle and applying pressure to the ground in children's playgrounds in the terminal buildings, both to raise awareness about sustainability and to strengthen the image of the airport operation. The data obtained from the interviews using these vignettes were evaluated with an inductive approach and content analysis.

As a result of the research, postmodern electricity generation methods were discussed with the help of professionals' observations and experiences, the themes of muscle strength and piezoelectric principle application evaluation were found and it was revealed that the advantages of these themes came to the fore.

*This study is derived from the master's thesis titled *Sustainable airport management: A research on the perception of energy production from human movement*

1. Introduction

The increasing consumption of conventional (non-renewable) energy resources creates a global energy crisis and environmental pollution, and civil aviation activities, with their intensifying operations day by day, cause the crisis and pollution in question. For this reason, the importance of the concept of sustainability is increasing in the civil aviation sector, as in every sector, and stakeholders such as airport operators, airlines and ground service providers frequently include sustainable practices in their operations. Stakeholders who integrate non-conventional (renewable) energy sources into their business processes and aim to reduce resource use by producing energy need more innovative investments over time. As sustainability becomes more and more prevalent in people's lives, obtaining energy from human activities is gaining popularity day by day. In line with the literature review and research, it has been determined that manpower energy, one of the non-conventional energy sources, is relatively weak in the field of civil aviation. In order to create the first step of

awareness about manpower energy and to evaluate expert perspectives, two separate vignettes (short stories) in which the existing manpower energy is effectively used in airport terminal buildings were directed to aviation professionals and interviews were held with them. The data obtained as a result of the interviews were evaluated with content analysis.

2. Literature Review

The rapid increase in energy demand is a major concern in recent years. Environmental problems caused by existing energy sources such as climate change and global warming force human beings to use non-conventional (renewable/alternative) energy sources (Mekhilef, Saidur and Safari, 2011, pp. 1777-1778).

While oil, natural gas, coal and nuclear energy constitute conventional energy sources, solar, wind, biomass, water power and human energy constitute non-conventional energy sources (Şenpınar, Gençoğlu, 2006, p. 49).

Non-conventional energy sources also include human power (Bidwai, Jaykar, Shinde, 2017, p.424).

Harvesting energy produced from muscle power and piezoelectric materials has an important place among human power-based non-conventional resources (Dokur et al., 2014, p.53).

Below, data obtained from the literature on muscle power and electricity generation with piezoelectricity are given.

Electricity Generation with Muscle Power

Studies have been carried out on producing energy by pedaling a bicycle since the 1950s, and developments are being made in the production and storage of energy day by day (Enerji Portalı, 2023).

In their study, Duraklar, Şen and Atasoy (2013) aimed to store the energy spent by customers in gyms by converting it into electrical energy in order to use it effectively and prevent it from being wasted.

In their study, Portakal, Adıgüzel and Sayar (2014) produced electrical energy by pedaling and stored this energy by transferring it to the battery and then used it to charge mobile phones and tablet computers. Thus, mechanical energy that could not be used effectively and wasted was transformed into electrical energy.

In their study, Bidwai, Jaykar, Shinde (2017) focused on obtaining energy from gym bikes in gyms because exercising in the gym has an important place in modern life and people's interest in gym exercises is increasing.

In their study, Zaman et al., (2017) aimed to collect electricity by using the energy obtained from human movement through the gym bike.

Yadav et al., (2018) believed that more effective use of manpower could be achieved with properly designed mechanisms and stated that the most suitable and effective technology to use manpower efficiently was bicycle technology.

Electricity Generation with the Piezoelectric Principle

The concept of piezo, which means pressure in Greek, was introduced by French scientists J. and P. Curie in the 18th century. The piezoelectric feature converts the mechanical energy in the electric field into electrical energy as a result of the pressure applied to the materials (Çalışır, Akçay, Sürmeli, 2020). The foundations of the application are considered to have been laid by Hasler, who positioned a piezoelectric implant in the ribs of a dog. Thanks to the positioned implant, 17 μ W of energy was produced. Starner placed the piezoelectric polymer in the sole of the shoe, thus creating the basis of wearable energy. He predicted that an individual weighing approximately 50 kilograms could produce 5 W electricity as he took a step (Tüfekçioğlu, 2014). Khaligh, Zeng, Zheng (2009); Wei, Hu, He, (2013); Aslan, Bilgin and Erfidan (2016); Khan et al., (2019); Qian, Xu, Zuo (2019), authors working on human power-based piezoelectricity, developed prototypes and created various simulations.

In the literature, the usage areas of electricity generation with the piezoelectric principle in road, railway and air transportation are included.

Highway Transports

The mechanical energy available on highways can be used for various purposes, such as powering traffic lights, monitoring the structural health of roads, and providing energy to self-powered vehicle weighing systems.

Dokur et al., (2016) developed a prototype of an electricity generation system using piezoelectric materials that benefit from vibration, intended to be applied in road and railway transportation.

In their study, Kim, Shen and Ahad (2015) simulated and tested two piezoelectric energy harvesting units that produce voltages ranging from 5 to 20 V.

Chen et al., (2017) designed an energy harvesting system consisting of a vibration-induced piezoelectric circuit for speed bumps on the road.

In their article, Papagiannakis et al., (2017) aimed to develop several piezoelectric prototypes that can collect energy from the movement of road traffic.

Jasim et al., (2017) aimed to develop a new piezoelectric transducer design with optimized geometry for harvesting the energy generated under vehicle load on the highway.

In their study, Li et al., (2018) conducted tests to determine the piezoelectric generating capacity of the road pavement and obtained a maximum voltage of 65.2 V.

Roshani et al., (2018) presented the results of a theoretical and experimental study aiming to develop a vibration-based road energy harvesting system.

Railway Transportation

The mechanical energy available in railways can be used for various purposes, such as powering railway structural health monitoring systems and providing energy to sensors and automatic warning systems.

Nelson et al., (2009) found the solution to the search for a long-term, low-maintenance power source for remote railway systems in the piezoelectric principle, since the railways, a significant part of which is located in relatively remote areas, are weak in terms of warning light systems due to the cost of the electrical infrastructure.

Pasquale, Soma, Fraccarollo (2012) converted the mechanical vibrations of railway vehicles into electrical energy through a piezoelectric energy collector. The harvested power was used to provide structural tracking energy in railway vehicles.

In their study, Tianchen et al., (2014) focused on collecting energy from rail vibration to power wireless sensors on the railway. Considering that the rail has vibration energy, they proposed a new method to harvest energy based on the piezoelectric effect.

In their study, Pourghodrat et al., (2014) aimed to collect energy from existing traffic to provide electricity to automatic warning systems as well as sensors in order to increase safety in railway transportation systems. They have shown that piezoelectric devices are applicable for low power applications in railway transportation systems.

Wang et al., (2015) examined energy harvesting from railway systems in their study.

In their study, Gao et al., (2016) proposed a 200 mm \times 170 mm \times 80 mm piezoelectric generator to collect the energy arising from the rails on the railway. They used a hydraulic system with an excitation force of 140 kilonewtons to simulate the situation.

Yang et al., (2021) presented an efficient railway-induced piezoelectric energy harvester to harvest energy from railway vibration and established the corresponding model. The proposed piezoelectric energy harvester was evaluated by laboratory experiments and theoretical analysis.

Air Transportation

Airports are structures built on a larger scale and more sophisticated in terms of both infrastructure and information structure, aiming to be the most comprehensive air transportation service providers connecting countries internationally. When looking at the daily operations of an international airport, it becomes clear that energy consumption is very high. Additionally, relying on fossil fuels to power airports and run operations on a daily basis lead to many

negative socio-environmental impacts. To date, several of the world's leading international airports have begun to adopt renewable energy, focusing on solar energy, towards reducing fossil fuel consumption and greenhouse gases.

Inspired by thinking differently since the adoption of solar energy at Kuala Lumpur International Airport (KLIA) in 2014, Chew et al., (2017) proposed another adaptation of renewable energy piezoelectric technology to KLIA as a feasibility study.

In their study, Agarwal and Sharma (2014) presented a piezoelectric system to be used to harvest vibration energy from airport runways.

Currently, there is a need to use alternative energy sources in passenger terminals of airports and railways around the world. Dhingra et al., (2012) examined the fundamentals of piezoelectricity in energy harvesting and carried out studies on obtaining energy from shoes, applications in terminals, and providing lighting from pedestrian traffic.

Kavirat (2017) proposed piezoelectric floors for use in densely populated airport terminal areas such as check-in counters, passport control, duty free and boarding gates.

Salim, Abdulrazig (2020) mentioned in their studies the importance of providing secondary solutions in energy production compatible with the environment and economy, due to the existence of constant energy demand, high costs and depletion of natural resources.

The authors, who carried out a theoretical study on generating electricity using piezoelectric materials in order to obtain sufficient and clean electrical energy, gave examples of the applications of piezoelectricity in various fields and also mentioned the use of piezoelectric systems at points of passenger traffic in airport terminals.

Airports want to create enjoyable experiences for their passengers. Heathrow Airport wanted to offer its visitors a unique, unforgettable, innovative and exciting travel experience and placed piezoelectric floors under the passengers' feet. They benefited from the high passenger traffic of one of the busiest terminals. Passengers can generate energy for lighting screens while walking on the walkway in the relevant corridor (Pavegen A, 2023).

The 'Power Floor' project was put into service at Heathrow Airport with the interactive corridor concept. Located at Heathrow Airport Terminal 3, the floor consists of a panel of 100 colored tiles that capture the kinetic energy from passengers' steps and convert it into electricity. More than 5,000 passengers pass through the corridor connecting the Terminal 3 waiting area to the departure gates every day. This mobility converts passengers' steps into electricity for 18 hours a day, providing kinetic energy that illuminates the area. The airport management has very positive thoughts about the possibilities offered by the relevant technology as a sustainable energy source for the future (Bilbao, 2023).

Trying to create a pleasant travel experience based on sustainability that its passengers will remember, Abu Dhabi Airport has built a 16-meter energy-producing walkway in the terminal, utilizing the piezoelectric principle (Pavegen B, 2023).

3. Methodology

3.1. Aim of Research

Although there is an incentive and tendency to use non-conventional energy sources in many sectors, this use is also valid for operations in the civil aviation sector.

The aim of the study is to create environments where passengers participate in energy production in terminal areas by determining the conversion methods of kinetic energy

arising from passenger mobility at airports into electrical energy.

In line with this purpose, the study aims to evaluate the perspectives of experts on post-modern energy production in the context of passenger mobility through prepared short stories.

For this purpose, the research question was determined as.

- How can sustainable energy production be contributed by using muscle power and piezoelectric principle in airport terminal buildings?

In order to achieve this goal, the importance of generating electricity with muscle power and the piezoelectric principle based on human mobility was emphasized, potential sustainable electricity generation methods that could be used in terminal buildings were directed to experts through vignettes, and suggestions were made by evaluating the validity and applicability of these methods.

3.2. Limitations of the Research

The basis of the research was to use the electricity produced by muscle power and the piezoelectric principle to power the computers at the check-in counters in the terminal or to provide illumination of certain areas. As a result of the research and interviews conducted, it has been concluded that these gains will not be at the desired level. The vignettes, which were created primarily to raise awareness and image, were directed to participants who continue their professional lives in the field of civil aviation and their opinions were sought. Interviews were held with seven professionals.

3.3. Research Method

The data obtained as a result of semi-structured interviews conducted after the vignettes created for the research question are transferred to the participant will be qualitative data. For this reason, qualitative research method was adopted in the study.

There are two basic approaches to analyzing qualitative data. These approaches; deductive approach and inductive approach. In the deductive approach, a structure or predetermined framework is used to analyze data. The researcher imposes his or her own structure or theories on the data and then uses these to analyze interview transcripts. This approach is useful in studies where researchers are already aware of the answers they obtain from interviews. The inductive approach involves analyzing data with little or no predetermined theory, structure, or framework, and uses the actual data itself to derive the analysis structure. Interview transcripts are descriptive of the study, but they do not provide explanation. It is the responsibility of the researcher to explore and interpret the collected data. The process of thematic content analysis, where data is analyzed manually or using computer software, is essentially the same. The researcher reads each participant's statement and makes notes in the margins with words, theories, or short phrases that summarize what they expressed. This is often called open coding. The aim is to provide a summary phrase or word for each element present in the participant's statements. Then, the researcher categorizes the words that summarize the participants' statements. The codings are collected in category lists. A list of up to twelve categories can be prepared. Category lists are also reduced and their final version is created. As a result, the researcher obtains an organized data set.

When the literature is examined, it is seen that there are different opinions about sample size in qualitative studies, and

the largest sample size in the relevant opinions is 50. Some opinions suggest that a sample size of 10 people is sufficient for qualitative studies if sampled from a homogeneous population (Sandelowski, 1995). According to Creswell (1998), a sample of 20-30 people is large enough to create a theory. Marshall et al. (2013) think that a sample of 20 people is small, a sample of 40 people is large, and a sample of 30 people is sufficient. Sandelowski (1995) states that a sample size of 50 people is too large a sample for a qualitative study. In addition, the sample size cannot be determined before the research, and it is argued that the research should be continued until data saturation is reached (Blaikie, 2018; Sim et al., 2018). According to Sim et al., (2018), the sample size should be in the range of 5-35 people for theory development research and 4-30 people for a case study.

If it is qualitative research conducted with very large data sets, computer programs may be more useful in the analysis process. However, researchers who want to use relevant programs and software must first receive appropriate training.

Analysis of qualitative data, of course, involves interpreting study findings. However, this process has some subjective features. There is a common belief among social scientists that there is no objective and definitive view of social reality. This situation causes the confirmability problem of qualitative data analysis. Therefore, there is a need for qualitative researchers' analyzes to be verified or approved by a third party. It is argued that verification and validation will reflect the analysis more rigorously and unbiasedly. Analyzes can be verified and validated by participants or peers. Analyzes made during participant verification are presented to the participants again for their approval. In peer validation, another qualitative researcher is asked to evaluate the analysis of the data. Participant verification involves going back to respondents and asking them to read the data analysis carefully to confirm or refute the researcher's comments. Although this arguably helps improve theme and theory development, the process is quite time-consuming and unless it occurs relatively soon after data collection and analysis, participants may have changed their perceptions and views due to the passage of time. Despite all the debate, there is no definitive answer regarding validity in qualitative analysis. However, all data collected needs to be analyzed in detail to ensure that the analysis process is systematic. There are two approaches to writing down the findings of qualitative research.

The first is called the traditional approach and is to report the main findings under each main theme or category, using appropriate verbatim quotations to illustrate these findings. The findings are presented in a separate discussion section. In the second approach, referred to as the combined approach, the discussion is included in the findings section. It is not available in a separate section (Burnard et al., 2008).

3.4. Participants and Data Collection Method

The participants of the research are professionals in the field of civil aviation. Vignettes prepared as a data collection tool were presented to the participants who had experience in airport operations, developed sectoral knowledge, and who were also airport customers and airline passengers, and then their opinions were taken in order to create a general idea in the light of their experiences.

Although vignettes were first used in quantitative research by psychologists in North America, they are also used in qualitative research. As vignettes are preferred in literature, they have become important for qualitative research.

According to Finch (1987), vignettes are short stories created in specific situations that require the interviewee to

respond. Stories have aspects of the context and enable certain forms of open-ended questions that are specific to the situation. According to Azman and Mahadhir (2017), stories are short depictions of typical scenarios that aim to find answers that will reveal values, perceptions, impressions and accepted social norms. According to Hughes (1998), vignettes are called concrete scenarios or short stories written about certain situations. The use of vignettes as a data elicitation technique encourages the expression of participants' perceptions, ideas, beliefs, and attitudes as they respond to or comment on concrete scenarios and situations as depicted. In qualitative research, vignettes are often used in conjunction with several other methods, such as interviews.

According to Tasar (2006), vignettes have the advantage of collecting in-depth information, especially in qualitative and small sample studies. In social sciences, vignettes are data collection tools that can be designed based on the opinions of experts in the field or on experienced situations. It should be noted that vignettes are not case studies and should be limited to 50 to 250 words and should not be too long. They should convey the situation in a simple and understandable way (Kemer and Aslan, 2022).

According to Campbell (1996), there are three steps to create vignettes. The first step is to determine the subject of the vignettes and to whom they will be applied. Next comes the creation of realistic and understandable vignettes for the people to whom the vignettes will be applied. The last step is to conduct a pilot study to test whether the vignettes are understandable, clear and appropriate to the target.

When creating vignettes, six factors should be taken into consideration: detail, understandability, credibility, environmental factors, structure and format. Details, although not numerous, should be given in a way that supports the vignette and helps it come to life in the person's mind better. Vignettes should be understandable, reflect realistic situations and be believable, describe the environmental factors of the situation well, and have a structure appropriate to the target. Although vignettes are mostly presented in written format, they can also be presented in the form of video or audio files (Kaya and Kaya, 2013).

In the study, firstly, the topic and the research question mentioned above were decided. Then, the appropriate vignette type was decided. Afterwards, vignettes were created. The vignettes created at this stage - based on the vignette creation steps of Campbell (1996) - were presented to doctoral students and their comprehensibility was tested. Then, opinions about the vignettes were received from two assistant professor, one lecturer and two research assistants. With all the feedback obtained, the options were revised and made ready for use. It was studied with purposeful sampling and maximum diversity was aimed. Qualitative data were collected through semi-structured interviews. Finally, the data obtained was analyzed with inductive content analysis.

Below is the first vignette created and directed to participants.

Vignette 1: Generating Electricity by Pedaling a Bicycle

In certain areas of the airport terminal buildings, there is an area with bicycles that produce electrical energy as they are pedaled. Mobile phones, laptops and tablets can be charged by using a bicycle in the area. By using the bike, the passenger will be able to use his own muscle power to power his electronic devices, while doing so will not have a negative impact on the environment and will also provide the mobility required for a healthy life. During a portion of the total travel time, the passenger will perform a different activity and have a more enjoyable time. In order to encourage the use of the

relevant bicycles, the passenger participating in the application will be provided with a discount coupon from contracted food and beverage service providers and the parking service. The amount of discount offered with coupons will increase in direct proportion to the duration of using the bike. During a half-hour cycling period, you will receive a '5% discount coupon' valid for food and beverage service providers, and a 'free use of 15 minutes of parking time' valid for parking facilities. Passengers will have the right to use this discount again at the same airport within one year.

- Based on the vignette above, which of the following options would you choose?

a) It would be an application that would interest me and support it. I would definitely take the time to participate.

b) It would interest me, but I would not spend time on application.

c) I wouldn't be interested. I would not want to spend time on this application during my time at the airport.

- Can you explain in a few sentences why you choose the option you chose?

Vignette 2: Piezoelectric Floor Application in Children's Playgrounds in Terminal Buildings

In order not to waste the energy that children already have; piezoelectric systems have been installed on the floors of playgrounds in certain areas of the airport terminal buildings.

Thus, points were created where the available energy that could not be used effectively was harvested. The passenger will want to benefit from the children's playground in the terminal buildings, aiming to ensure that the accompanying child passenger has a more enjoyable time during the total travel time. In areas where entertainment opportunities are offered enriched with various toys, children will contribute to electricity production as they move and apply pressure to the ground. The energy obtained from the movement of children will power and operate the LED strip lighting equipment in the area and will flash in different colors. Thus, by seeing the energy they produce being used, children will begin to gain environmental awareness at an early age, and their awareness of the subject will begin to develop.

- Based on the vignette above, which of the following options would you choose?

a) It would be an application that would interest me and support it. I would definitely take the time to participate.

b) It would interest me, but I would not spend time on application.

c) I wouldn't be interested. I would not want to spend time on this application during my time at the airport.

- Can you explain in a few sentences why you choose the option you chose?

3.5. Analysis of Data

The process of analyzing qualitative data includes classification and interpretation in order to develop evaluations to gain meaning from the collected data. Analysis enables obtaining logical meanings from the essence of the data by reducing the amount of data obtained (Çelik, Baykal and Memur, 2020).

According to Creswell (2002), qualitative data analysis is classified in six steps. The six steps in question are; preparing and organizing the data for analysis, coding the data, creating

themes, reporting the findings, interpreting the findings and testing the accuracy of the findings.

According to Wolcott (1994), qualitative data analysis is divided into two: descriptive analysis and content analysis. Content Analysis is an in-depth analysis of the data obtained and enables the creation of themes. The basis of content analysis is to integrate similar data into some themes and interpret them for the target audience.

In the research, inductive content analysis was performed to reveal the concepts and relationships of the data obtained by coding, dividing into categories and themes.

3.6. Compliance with Ethical Rules

An ethics committee application was made for the research on 13.04.2023, numbered E-60850919-300-2300020021. The ethics committee application numbered E-87914409-050.03.04-2300025331 was examined by the Social and Human Sciences Scientific Research and Publication Ethics Committee on 16.05.2023. The research was found ethically appropriate.

4. Findings and Discussion

Within the scope of the research, professionals in the field of civil aviation were interviewed and findings were presented. Participants were given codes as P1, P2, P3, P4, P5, P6 and P7. Demographic information of the professionals participating in the research is given below.

Table 1. Demographic Information of Participants

Participant	Gender	Age	Organisation - Flight Frequency
P1	Male	18-28	Airline- 15 times a year or more
P2	Female	18-28	Others- Less than 5 per year
P3	Male	28-38	Ground Handling Service- 15 times a year or more
P4	Male	28-38	Ground Handling Service- 5- 10 times a year
P5	Female	28-38	Others - Less than 5 per year
P6	Female	18-28	Airline- Less than 5 per year
P7	Female	48+	Others- 15 times a year or more

Table 1. contains information about the gender, age, organization they work for and flight frequency within a year of the participants coded as P1, P2, ... P7. Participants, in the civil aviation sector, work in ground handling services, airline companies and others. The participants, who had the opportunity to closely observe passengers' wishes and needs and hear their opinions, are experienced experts who follow current developments on sustainability, airport and environmental issues, and have been to various international airports.

Table 2. Frequency Values of the Options Marked According to the First Vignette

Option	Frequency
It would be an application that would interest me and support it. I would definitely take the time to participate.	3
It would interest me, but I wouldn't take the time to practice it.	4
I would not be interested. I would not want to spend time on this application during my time at the airport	0

As seen in Table 2., no participant chose the "I would not be interested." option for the first vignette titled Electricity Generation by Pedaling a Bicycle. This shows that the vignette attracts the attention and interest of the participants. The option "It would interest me, but I would not take the time to practice it" (f=4) was the most preferred option. Then, the option 'It would be an application that would interest me and support it' was preferred.

Some of the prominent expressions of the participants about the first vignette are given below.

'Passengers need to charge their phones and computers at airports. It is a great experience that they do this in an environmentally friendly way with their own actions. Based on my observations, I think that such an application could be widely used, for example, at Istanbul Airport. Because it is an airport where transit flights take place very frequently.' P5.

'It would be an application that would interest me and support it. I would definitely take the time to participate. As a result of my observations on flights and in the terminal, I think that the application would be more preferred if the discount coupons were a little more encouraging.

In 2013, I won a t-shirt with a similar application at Bangkok Airport. I've kept it ever since.' P3.

'I found the discount amounts generally low. When I think about the passenger profile, I believe that passengers should be encouraged a little more if intensive usage is desired. Especially when we target the young generation, the application may be more attractive if there is the opportunity to watch some content on a screen while cycling.' P1.

Table 3. Frequency Values of the Options Marked According to the Second Vignette

Option	Frequency
It would be an application that would interest me and support it. I would definitely take the time to participate.	7
It would interest me, but I wouldn't take the time to practice it.	0
I would not be interested. I would not want to spend time on this application during my time at the airport	0

As seen in Table 3., for the second vignette titled Piezoelectric Flooring Application in Children's Playgrounds in Terminal Buildings, all participants (f = 7) chose the option "It would be an application that would interest me and support it. I would definitely take the time to participate."

Some of the participants' prominent statements about the second vignette are given below.

'While the existing children's playgrounds are already an activity area that I like, especially because it brings together children from different cultures, the fact that it serves such a purpose has created extra positive ideas. Instilling and developing awareness in children at a young age through play will be more effective and memorable. The fact that children do not waste their energy and do not get bored while waiting for the plane shows the versatility of the application. When you look at it, it is actually an application that will raise awareness of adults as well.' P6.

'It is an application that I think will be very effective in broadening children's horizons and developing their imagination.' P4.

'This will definitely be an application that a passenger traveling with his/her child will be interested in. Playgrounds will also be effective in helping the child release his energy and have a calmer flight. While it is a remarkable practice for the child, I think it will also raise awareness for their parents.' P2.

'While the journey is a stressful process for the passenger, it can become an even more stressful process for the child. Based on my flight operation experiences, I have observed many times that children become restless during this process. Flights create some physiological imbalances in children... Especially in terms of children having fun and spending time with toys - even if they do not produce energy - it is an area that will relax parents and children and make the journey more comfortable. In addition, it will be interesting for children as it contributes to electrical energy. In addition, I believe that the earlier sustainability awareness is ingrained in the child, the more active role it will play in the future. Although there is a possibility that younger children may not understand the process, awareness is created in the first place. Even if the relevant acquisition is not achieved at that moment, it will develop when the child grows up.' P5.

Below are the codes based on the quotes from the interviews held regarding the first vignette titled Electricity Generation by Pedaling a Bicycle and the second vignette titled Piezoelectric Flooring Application in Children's Playgrounds in Terminal Buildings.

As a result of the interviews of the first vignette, insufficient discount, more incentives, sweating, fatigue, insufficient time, interesting, rush to catch up, experienced, higher participation in domestic flights, an application that will give pleasure during the stressful journey, environmentally friendly, fun, healthy life, sustainability, tiring travel process and innovative application codes were created.

As a result of the interviews of the second vignette, the need for sufficient time, the hygiene provided, attractive, interesting, the child's energy boost, the child being calm during the flight, attention-grabbing, awareness raising, parental awareness, positive perspective towards the airport, an effective application on children, stressful travel process, even more stressful travel process for the child, physiological imbalance and unrest, a pleasant practice, comfortable and relaxing, sustainability, intercultural interaction, effective purpose, awareness formation, versatility codes were created.

Table 4. Main Category (Theme) and Categories of the First Vignette

Main Category (Theme)	Categories	Temporary Categories
Human movement-based energy production evaluation of possible muscle power applications suitable for in airport terminal	Advantages	Attractive application Sustainable application Insufficient earnings
	Disadvantages	Physical negativities Time limit

In Table 4., as a result of the interviews for the first vignette, the categories were determined as advantages and disadvantages. The theme has been determined as human movement-based energy production evaluation of possible muscle power applications suitable for in airport terminal.

Table 5. Main Category (Theme) and Categories of the Second Vignette

Main Category (Theme)	Categories	Temporary Categories
Human movement-based energy production evaluation of possible piezoelectric principal applications suitable for in airport terminal	Advantages	Attractive application Calming down Having consciousness Increased business image Active application Sustainable application Various achievements
	Disadvantages	Time Limit

In Table 5., as a result of the interviews for the second vignette, the categories were determined as advantages and disadvantages. The theme has been determined as human movement-based energy production evaluation of possible piezoelectric principal applications suitable for in airport terminal.

When the findings of the first vignette are examined, it is possible to comment that the application is accepted and attracts attention because there are no participants who choose the option 'I would not be interested. I would not want to spend time on this application during my time at the airport.' There are some diverging answers when it comes to taking the time to participate. The main reason for this is that participants do not want physiological consequences such as sweating and fatigue. Additionally, the amount of discount coupons valid for food and beverage service providers and parking facilities was found to be low.

A significant majority evaluated the application as an innovative application that adds movement and fun to the journey process, which can be stressful and boring, and supports healthy living.

The participant coded as P3 stated that he encountered a similar practice at Bangkok Suvarnabhumi International Airport in 2013. He used bicycles there to try the application that interested him and added that he still keeps the T-shirt he earned as a result of pedaling as a souvenir. It contributed to

one of the participants in the study being able to comment as someone who had experienced a similar application before.

The idea of using bicycles, which have a sustainability dimension and provide the energy needed in an environmentally friendly way, was supported by all participants. The answers given were shaped by the fact that the participants have been involved in the civil aviation sector for years, that they follow the current developments on climate, environment and sustainability, and that they have an awareness that all civil aviation stakeholders meet on a common denominator regarding sustainability.

When the findings of the second vignette were examined, it was seen that 'It would be an application that would interest me and support it. I would definitely take the time to participate' was preferred by all participants. The fact that the application of piezoelectric flooring in children's playgrounds in the terminal buildings was supported by every participant shows that the application is interesting and accepted. It is thought that this practice, which emphasizes sustainability, was approved by the participants because it supports the formation of awareness by aiming to raise awareness at an early age in the target audience.

P2 stated that the target audience will not only be limited to children, but also parents will be aware of the subject in the statement, "I think it will be a remarkable application for the child and raise awareness for their parents." From this perspective, it can be seen that it is not an application limited only to children, but has a wide impact area. Just as stated in the interviews about the first vignette, it has been a supported practice because it allows children and parents to have more fun before the journey, which can be stressful and boring, allows children to get rid of their excess energy, and this is reflected in their attitudes and behaviors in the cabin during the flight.

5. Conclusion

The trend towards non-conventional energy sources affects airports as well as all stakeholders in the civil aviation sector. Airports aim to use non-conventional energy sources such as solar, wind and biomass effectively. The manpower provided by their intense traffic formed the basis of this research. Electricity production from the human power energy in question; It has been examined under two subheadings: muscle power and electricity production with the piezoelectric principle.

There are many studies in the literature about electricity production by pedaling a bicycle within the scope of electricity production with muscle power. Electricity production studies with the piezoelectric principle are also frequently included in the literature. There are also examples of use in civil aviation and airport terminal buildings in studies and projects that reveal the areas of use of piezoelectricity in various modes of transportation.

In this research, scenarios of muscle power and piezoelectric principle, which are methods of electricity generation with human energy, that can be applied in airports are included. The opinions of aviation professionals on the relevant subject were received through the prepared vignettes. As a result of the content analysis, two separate themes belonging to two vignettes were obtained.

The theme of human movement-based energy production evaluation of possible muscle power applications suitable for in airport terminal consists of advantages and disadvantages categories. The advantages category consists of temporary categories such as attractive application and sustainable

application, and the disadvantages category consists of temporary categories such as insufficient earnings, physical disadvantages and time constraints. Temporary categories, insufficient discount, more incentive, sweating, fatigue, insufficient time, interesting, rush to catch up, experienced, higher participation in domestic flights, an application that will give pleasure during the stressful journey, environmentally friendly, fun, healthy life, sustainability, tiring journey process and innovative application was found.

Although the first vignette, titled Electricity Generation by Pedaling a Bicycle, was described as meaningful and interesting by aviation professionals, it was evaluated as inadequate in terms of the incentives offered. Since the application requires physical effort, the feeling of fatigue and sweating it may cause have created hesitations against the application. In addition, it was concluded that it would not be possible for passengers who do not have enough time at the airport before their flight to participate in the application. On the other hand, the positive aspects of the application were determined by the participants as making a difference in terms of sustainability, having an environmentally friendly and innovative vision, supporting healthy living, and making waiting time fun.

The theme of human movement-based energy production evaluation of possible piezoelectric principle applications suitable for in airport terminal.

The advantages category consists of attractive application, calming down, awareness, increased business image, effective application, sustainable application, various gains, and the disadvantages category consists of time limitation. Temporary categories, sufficient time requirement, provided hygiene, attractive, interesting, the child's energy release, the child's calmness during the flight, remarkable, awareness raising, parental awareness, positive perspective towards the airport, an effective application on children, stressful travel process, for the child more stressful travel process, physiological imbalance and restlessness, a pleasant practice, comfortable and relaxing, sustainability, intercultural interaction, effective purpose, awareness formation, versatility was found.

In the second vignette, titled Piezoelectric Flooring Application in Children's Playgrounds in Terminal Buildings, all aviation professionals interviewed said, "It would be an application that would interest me and support it. I would definitely take the time to participate." It was stated that the areas cannot be used effectively if passengers have a time limit before the flight at the airport, and the necessity of ensuring hygiene conditions as a result of international activity in the playground was emphasized. It has been a supported practice, especially for children, as it makes the stressful part of the journey fun, allows them to relieve excess energy, and raises awareness about sustainability and environmentally friendly energy production. It has been a supported practice, especially for children, as it makes the stressful part of the journey fun, allows them to relieve excess energy, and raises awareness about sustainability and environmentally friendly energy production.

All these evaluations were made as a result of the experiences and opinions of professionals in the civil aviation sector. Their knowledge and awareness about sustainability, which is an important concept today, and their good knowledge of terminal operations and passenger profiles played a role in their presentation of relevant opinions.

The expected outputs of the research are that postmodern energy production applications based on human energy have a positive impact on the image of the airport and attract attention in the global showcase.

As a result of the findings obtained, it is thought that human movement-based post-modern energy production methods that can be implemented in airport terminals will form the basis for future research and operations.

In future studies, vignettes can be directed to different groups, taking into account the generation gap, and interviews can be held with children who are old enough to use playgrounds, accompanied by their parents. As a result, different results may be obtained from the research.

Ethical approval

An ethics committee application was made for the research on 13.04.2023, numbered E-60850919-300-2300020021. The ethics committee application numbered E-87914409-050.03.04-2300025331 was examined by the Social and Human Sciences Scientific Research and Publication Ethics Committee on 16.05.2023. The research was found ethically appropriate.

Conflicts of Interest

The authors declare that there is no conflict of interest regarding the publication of this paper.

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