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Environmental Innovations in the Aviation Industry During the COVID-19 Pandemic

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Abstract

Background and Aim: The innovation of the aviation industry during the COVID-19 pandemic is the development of new innovations. It happens several times in the aviation industry among airlines and airports. Many strategic plans have been adjusted to make technological developments including the development of innovations that are more environmental.

Materials and Methods: This article presents an analysis of the environmental innovations of the aviation industry during the COVID-19 pandemic. It includes studying the innovation development of airlines and airports both in Thailand and abroad to create knowledge, understanding, and awareness of the importance of the environment and innovations that happen during the COVID-19 epidemic. Moreover, it is also an innovation that has a positive effect on service users around the world.

Results: In accordance with WHO norms, steps are taken to lower the risk of COVID-19 infection, including developing innovative ideas to improve passenger service. In addition, there is a rising concern for the environment, with organizations like ICAO and IATA working hard to limit greenhouse gases like carbon emissions, which are directly linked to global warming. The gathering of global leaders has taken place on multiple occasions to encourage the reduction of carbon emissions into the atmosphere. Hence, starting this investment is a wise decision. The money will also be used to plant trees throughout the world as part of new developments. In order to receive discounts on purchases by developing innovations for the greatest efficiency and effectiveness, passengers must be aware of ways to minimize carbon emissions.

Conclusion: Current developments in the aviation sector are regarded as a crucial condition in the global aviation sector. Since the previous COVID-19 epidemic, airlines have faced challenges, particularly with regard to revenue, which has limited flights in various countries, preventing airlines from being able to fly 100% of the time in the past. There are also rising costs for the COVID-19 epidemic's prevention, including labor costs. Yet, collecting fuel surcharges for air travel or charging a fuel fee while raising prices is one way that airline corporations might save expenses. It is, nevertheless, impossible to raise prices too much due to increased market rivalry due to a variety of variables. In the midst of the epidemic, the number of recently established airlines has surged while the number of passengers has decreased by more than 70%. However, the money will also be used to plant trees throughout the world as part of new developments. In order to receive discounts on purchases by developing innovations for the greatest efficiency and effectiveness, passengers must be aware of ways to minimize carbon emissions.

Keywords: Environmental Innovation; Aviation Industry; Epidemic of COVID-19

Introduction

The aviation industry has undergone significant innovation during the COVID-19 pandemic with each airline having its own innovation institute to research and create various innovations that are practical, in line with people's lives during the epidemic, reduce human contact, and also adhere to environmental preservation and lower greenhouse gas emissions.

The Carbon Offset and Reduction Program for International Aviation (CORSIA. 2022) is a global project to address emissions from international aviation travel. In accordance with a 2016 ICAO agreement, airlines must begin tracking and reporting emissions in 2019 and purchase emissions reduction equipment created by initiatives in other industries to keep them under check. It addresses reducing the rise in carbon dioxide emissions over 2020 levels starting in 2021 and continuing through 2027. The majority of states will be required to take part in CORSIA, which will go into force on practically all international routes. Only states with few roundtrip operations will be exempt after 2027;

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being designated as least developed, small/landlocked islands or CORSIA may have an impact on airlines. If the following conditions are satisfied: At takeoff, the aircraft weighs more than 5,700 kg, there will be emitting 10,000 tons of carbon dioxide annually on trips outside of the United States. It has been running for over three years, and both states are affiliated with the airline it is flying and is currently participating in CORSIA's pilot program as a result of the rise in international air travel. In compliance with these requirements, aviation organizations are under increasing pressure to take measures to minimize carbon emissions. International airlines can lessen their environmental effect by adhering to CORSIA and doing so in accordance with global regulatory standards (ISO Certification Institute, 2022). It is evident that many nations throughout the world are becoming more environmentally conscious, which has led to a number of significant conferences on the subject, including the aviation industry, which is attempting to reform and generate innovations. Thereafter, it will cut down on carbon emissions into the global atmosphere.

Paper Scope: To study and analyze Environmental innovations in the aviation industry during the COVID-19 pandemic And application of relevant research

Aviation Industry during the Pandemic

With the COVID-19 outbreak, the aviation business or industry has adapted by employing aircraft to travel for other purposes instead, that is, adapting to move commodities and send medical aid to other countries. This adaption can be modified for the circumstance with the worldwide impact; airlines are able to modify their fleet in several ways. There are three different kinds of passenger aircraft to accommodate the use: (1) using passenger planes to transport goods by loading cargo onto passenger seats and using nets to secure the cargo in place; (2) accepting temporary cargo operations by removing passenger seats to increase cargo capacity; and (3) permanently converting passenger aircraft into freighters (Worakamnueang, R., 2020, cited in Laphet, J., & Klinsreesuk, W., 2022). World Health Organization (hereafter WHO) said that fever (temperature greater than 37.5 degrees Celsius), cough, exhaustion, loss of taste in the tongue, nasal congestion, runny nose, diarrhea, or skin rashes are the most typical symptoms of COVID-19. Besides, skin tone varies depending on the size of the fingers and toes. These symptoms are typically It's gentle and develops gradually. Mild symptoms are present in some affected individuals; 80% of individuals recover without the need for hospitalization. According to the most recent studies, the chance of catching COVID-19 is ten times higher when people cannot smell or have a sense of taste than it is if you're feverish, coughing, or sneezing, which they can still distinguish some flavors, such as salty or sweet, in food. Meanwhile, those who have lost the capacity to smell will not be able to distinguish flavors properly. In about 1 in 5 COVID-19 patients, respiratory problems and severe symptoms are present. Furthermore, it was discovered that some groups, such as the elderly and those with inherited illnesses like cancer, high blood pressure, diabetes, or heart disease, tended to experience more severe illnesses than other groups. Nonetheless, everybody has a risk of contracting COVID-19 and exhibiting serious symptoms as well. Stiffness, a painful throat, and a decrease in smell are other warning signals from air quality issues. Airlines, therefore, are cautious about tourism due to travel and the aviation sector. Several chairs have been arranged close to one another promoting the spread of illnesses that have been mentioned. Thus, the requirements utilize alternative revenue-generating strategies to aid the company in further halting the development of the COVID-19 outbreak as certain airlines are unable to run smoothly.

Chantarapanich, R., (2021) has mentioned The Impact and Adaptation of the Airline Business in the COVID-19 Outbreak Situation. The objective of this academic article on the Impact and Adaptation of Airline Business in the COVID-19 Outbreak Situation is to present a study and an analysis of the impact and adaptation of airline business arising from the COVID-19 outbreak situation by studying from academic articles, research studies, report, and statistical data on airline business at the end of 2018-2020. The subject matter of this article consists of the COVID-19 pandemic that caused international travel to be interrupted due to various countries being in lockdown which affects the world economy and also the economy of Thailand. The result of airline service suspension is a decrease in air transportation revenue. Therefore, airlines have to find the methods and measures to deal with this situation for their survival such as the conversion of a passenger aircraft into a cargo aircraft. Currently,

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several airlines have converted their passenger aircraft such as Lufthansa, Korean Air, Emirates, Finnair, Austrian Airlines, Swiss Air, and Air Canada. Moreover, airlines offer similar services in domestics such as providing pointless flights, selling food, and airlines merchandise in a variety of ways

COVID-19

WHO (2019) Coronavirus disease (COVID-19) is an infectious disease caused by the SARS-CoV-2 virus. Most people infected with the virus will experience mild to moderate respiratory illness and recover without requiring special treatment. However, some will become seriously ill and require medical attention. Older people and those with underlying medical conditions like cardiovascular disease, diabetes, chronic respiratory disease, or cancer are more likely to develop serious illnesses. Anyone can get sick with COVID-19 and become seriously ill or die at any age. The best way to prevent and slow down transmission is to be well-informed about the disease and how the virus spreads. Protect yourself and others from infection by staying at least 1 meter apart from others, wearing a properly fitted mask, and washing your hands or using an alcohol-based rub frequently. Get vaccinated when it's your turn and follow local guidance. The virus can spread from an infected person's mouth or nose in small liquid particles when they cough, sneeze, speak, sing, or breathe. These particles range from larger respiratory droplets to smaller aerosols. It is important to practice respiratory etiquette, for example by coughing into a flexed elbow, and to stay home and self-isolate until you recover if you feel unwell.

Department of Disease Control, Thailand (2019) new strain of coronavirus is a family of viruses that cause illnesses ranging from the common cold to more severe diseases such as Middle East Respiratory Syndrome (MERS-CoV) and Severe Acute Respiratory Syndrome (SARS-CoV). The new strain has never been seen in humans causing respiratory illness in humans and can spread the infection from person to person by this virus. It is first discovered in an outbreak in Wuhan, Hubei Province, People's Republic of China in late 2019. Symptoms of the 2019-nCoV include respiratory symptoms, fever, cough, shortness of breath, and difficulty breathing very severe. Still, it can cause complications such as pneumonia, pneumonia, kidney failure, or even death infection spread. The virus is likely to have an animal as a source of disease; it is mainly spread through contact with an infected person via droplets from coughing, sneezing, snot, and saliva. However, there is currently no evidence to support this. The virus is transmitted through contact with contaminated surfaces and contacts with the mouth, nose, and eyes. It can also be transmitted via the Fexo-oral route. According to Our World in Data, more than 669 million people are currently infected worldwide, and there are still more than 6.8 million deaths, as of January 24, 2023.

Innovation in Global Aviation Industry

Airlines all around the world are constantly enhancing their offerings. For instance, Cathay Pacific has introduced a luxury travel lifestyle brand that satisfies consumer demands, particularly in the aftermath of the COVID-19 epidemic. Customers will be able to take advantage of new promotions, benefits, and alliances thanks to the new Standard Chartered Cathay Mastercard. With each swipe of your card, you may now begin to accrue Status Points and Asia Miles. The service was further created for long-distance shaking. The airline introduced the fuel-efficient Airbus A321neo in August 2021 to improve mobility in the area and lower carbon emissions. Also, it offers comfort, discretion, and additional room for luggage storage. The A321neos, which has been modified to offer the world's first in-flight entertainment system, raises the bar for regional travel. Being the first airline to install ultra-high resolution 4K TVs in every seat on the aircraft has given it an advantage in terms of the customer experience and environmental effect. In economy class, the screen has been improved to 11.6 inches. moreover, the extra-large 15.6-inch display is in business class (Cathay Pacific. 2023)

In terms of waste reduction, Etihad Airlines has improved by using eco-friendly packaging is one of the things that you may do. Furthermore, it is the first airline in the UAE to employ electronic technical records, or eTech logs, in airline operations. In order to create the foundation for a paperless airline, we have teamed together with the General Civil Aviation Authority (GCAA). Etihad has collaborated with Tencent to establish its own Etihad mini-program on WeChat - China's well-known messaging app, which is also part of the COVID-19 channel. Via a partnership with SITA, this initiative will enable us to communicate with passengers without requiring them to download a separate app or user interface to enable our cabin staff to finish all check-in processes on their phones prior to the start of the flight. Moreover, Etihad Airlines, a project of the Sustainable Bioenergy Research Consortium,

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achieved history by conducting the first commercial flight in history utilizing some locally generated biofuels (SBRC).

One of the biggest airline businesses in the world, Lufthansa, owns Swiss International Air Lines and Edelweiss. To remove carbon dioxide from the environment and recycle carbon dioxide, it has teamed up with Synhelion, a startup that specializes in the creation of renewable energy, and Climeworks, a business that specializes in the study and development of plant species and plant components. A collaborative contract to create synthetic fuel for commercial Aero planes has been struck. The objective is to create a synthetic fuel for use in aircraft engines that is similar to fossil fuels and will cut carbon dioxide emissions by 50% by 2022 and by 100% (zero emissions) by 2030. As a substitute for kerosene or petroleum, Synhelion is a pioneer in the production of synthetic oil, often known as a solar fuel. Solar fuel is created with the intention of transforming solar energy into carbon dioxide and water, which is currently utilized as aviation fuel. (Hydrocarbon substances), sometimes known as synthetic crude oil. It may be used to increase the quality and create aviation fuel. By 2030, it is anticipated that the business will be producing solar fuel for use in commercial and industrial settings through the methane gas produced from solar energy. Compared to using kerosene oil, this will contribute to a reduction in CO2 emissions of more than 50%. It is anticipated that the 25,000-square-meter facility will still be in operation in 2024 and be able to generate more than 5,000 tons of synthetic oil annually (Ministry of Foreign Affairs, 2022).

Amankwah-Amoah, J., (2021) COVID-19 pandemic and innovation activities in the global airline industry: A review. Despite the valuable contributions of scholars to the COVID-19 pandemic, limited scholarly attention has been paid to the opportunities unleashed by the crisis. As many industries have been turned upside down and markets rendered uncertain, the crisis is also propelling waves of innovation activities. In this paper, we developed the concept of "CoviNovation" to denote the firm's innovation emerging from, rooted in, or accelerated by the crisis. Our analysis yielded insights on innovations inspired by COVID-19 across the global airline industry, including inflight social distancing, utilizing touchless technologies at airports, disinfecting aircraft with UV, open-middle-seat policy, accelerated use of biometrics in check-in, and COVID-19 insurance. The theoretical and practical implications of the COVID-19-inspired innovations examined.

ICAO Secretariat and the Solar Impulse Foundation ICAO embraces Innovation The First Industrial Revolution used power from water and steam to mechanize the production of goods. The Second Industrial Revolution harnessed electric power to turn it into mass production. The Third one used electronics and information technology to unleash the full potential of automation. On environmental protection, fast-paced innovative, and green solutions in aviation are being pursued to decarbonize the sector. Various types of drop-in sustainable aviation fuels (SAF) are already available for use in aircraft, and further CO2 reductions are being pursued via new aircraft technologies and operational procedures (ICAO. 2022).

Today's innovations are very important to the aviation industry in order to reduce carbon emissions to the atmosphere Including reusing waste To create more value, it is the responsibility of aircraft manufacturers. And airlines that will help reduce the amount of waste Including reducing emissions of toxic gases as well.

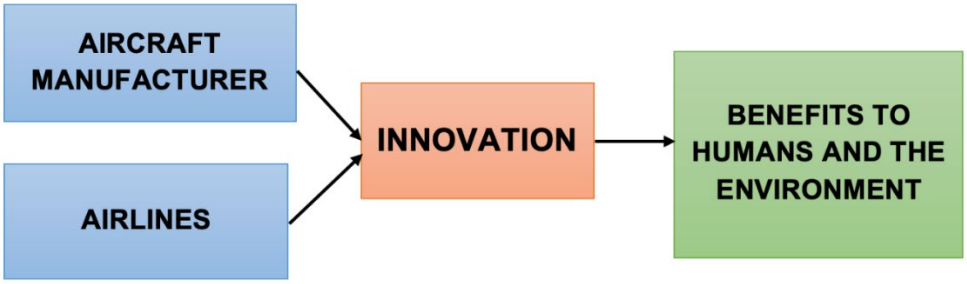

Figure 1: Summary of innovations in the aviation industry

Innovation in the aviation industry in Thailand

Management System Certification Institute (Thailand): MASCI has introduced a verification service for the International Aviation Sector Carbon Offset and Reduction Program (CORSIA) to assist those seeking Flight Operations (Aeroplan operators). It can operate in accordance with ICAO regulations as well as those of the Civil Aviation Authority of Thailand in order to uphold ICAO's

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commitments to the International Aviation Sector Carbon Dioxide Offset and Reduction Program, an aviation environmental measure to lessen the amount of greenhouse gas emissions that contribute to global climate change. Management System Certification Institute (Thailand): MASCI development industry is registered as a validation body and is a validation and verification body (Validation and Verification Body) recognized by the UNFCCC for the certification and verification of CDM projects, Effectiveness and Verification of Greenhouse Gas from Thailand and Greenhouse Gas Management Organization's T-VER Project (Public Organization). The ISO Certification Institute employees are skilled and knowledgeable in GHG validation and verification procedures - having work knowledge of the demands, expectations, and procedures of flight operators. In addition to competent, prompt service that complies with global management standards. Management System Certification Institute (Thailand): MASCI has created a GHG validation and verification system in accordance with ISO 14065 and has received accreditation from the National Standards Council. This is a government body that certifies the air transport system as a whole ICAO - CORSIA SPECIFIC REQUIREMENTS. In accordance with worldwide standards, the ISO Certification Institute assists airlines in adhering to local, state, and federal requirements (CORSIA. 2022).

Matnangern, T., (2021) Under the Next Normal Trend: Passenger' Expectation On Service Innovation From Full-Services Airlines. The purpose of this research is to study and find a line that will evaluate the airline as a Full-service airline, which is affected by the epidemic of COVID-19. Adding service model guidelines in order to help build competitiveness from the situation, the passengers' demands that have changed due to the impact of the spread of the COVID-19 virus, have more specific requirements on the safety of air travel related to the prophylactics. Besides, they will be able to ensure travel with a sense of security and less anxiety from infection. Therefore, airlines have studied the guidelines in advance preparation to provide service to passengers in the future or in the next normal situation. Afterward, it will be able to help create competition for airlines including their part in the development of sustainable competitiveness in the future of the airline themselves as well.

The global economy is fueled by the aviation sector. Whether it be intercontinental freight or passenger travel, dependable service that is quick and secure. Hence, it is what the service consumers anticipate. The aviation industry's center of gravity is the airport that serves as a driving force for industries in other fields, such as air travel, and management of the tourism industry's supply chain, including foreign investment. It functions as an impressive welcome area for airport guests and gives travelers a sense of security. The airport functions as a location to rest before taking off. Airports are crucial for providing services and infrastructure for companies involved in air transportation, and they also play a significant macroeconomic and microeconomic role in the development of the national economy. The operators of airport businesses have major objectives to "create client pleasure" and "create a high performance for the firm." However, the airport industry faces several difficulties (Difficulties), including commercial difficulties like the aviation industry's explosive development. Meeting these issues may be difficult due to regional rivalry, and natural and societal challenges including bad weather, catastrophes, terrorism, political turmoil, or passenger expectations. The objective is to increase customer satisfaction and provide healthy revenues for the company. Because of this, "innovation" is significant to today's aviation business owners.

There are several ways to innovate in the aviation sector because it is a sector that is interconnected with a wide range of other sectors, including the travel and transportation sector, the service sector, and the retail and wholesale sectors. Thus, innovation may happen at many levels and along the value chain. From incremental innovation, which makes a product or service better and more effective, to disruptive innovation, which fundamentally alters a product or service's original form while also meeting previously unmet consumer wants. Technology also plays a significant role in the industry's innovation. It is because the aviation sector has such high standards and is subject to a number of rules about security, customer service, and technology. Thus, it is beneficial to improve products and services to meet the set requirements.

Environmental Innovation in the Aviation Industry

According to Sukkong, P., (2022), the aviation sector has historically come under fire as one of the businesses that produce the most carbon dioxide. One of the factors contributing to global warming, it has now turned into a "global mess." Indeed, environmentalists have long kept an eye on this problem. While several airlines are already attempting to transition to eco-friendly biofuels. At the Farnborough Airshow outside London in mid-2022, Airbus and CFM International flew the world's largest passenger aircraft, the Airbus A380, to demonstrate the use of a high-tech open-fan engine that reduces carbon dioxide emissions by up to 20%. The A380 is a large aircraft known as the 'Super Jumbo' as we know

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it despite being big, roomy, comfy, and popular with tourists. Due to the COVID-19 epidemic and high maintenance expenses, commercial airlines are placing fewer orders which leads many airlines to favor small and medium-sized aircraft over big aircraft when flying long distances. As part of a revolutionary innovation demonstration project for sustainable engines, or Revolutionary Innovation for Sustainable Engine, CFM, a joint venture between GE and Safran Aircraft Engines, develops breakthrough propulsion technologies (RISE). This program's objective is to educate other aviation business owners on how engines, wings, and aerodynamics display fuel efficiency. Comparing it to today's most efficient engines, its CO2 emissions are cut in half, and it is completely compatible with the SAF biofuel, which is ecologically benign. By 2050, the world will transition to a net-zero economy, and it appears that this new technology may contribute to that effort.

Airlines and other aviation or other stakeholders can sell CO2 emission reductions for compliance purposes or voluntarily pay compensation through the Aviation Carbon Exchange, or ACE, a marketplace for qualified CORSIA emissions units established by IATA. In a secure and user-friendly trading environment, ACE is the middleman that provides the most accurate information on the cost and accessibility of managing carbon emissions. IATA Settlement Systems and Clearing House will provide easy and risk-free payment for airlines trading on ACE. Any airlines, even those that are not IATA members, are welcome to participate in the exchange. These fees may be modified for carbon market players that desire to offer CORSIA-compliant emissions reductions. This also aligns with advancements in the aviation sector related to the environment. Moreover, each airline is still dedicated to creating environmentally friendly technologies, such as recycling garbage produced by different inventions that will assist decrease waste and protect the environment utilizing the ideas that airlines come up with (IATA. 2022).

At Airbus headquarters in the south of France, there are flying machines made of composite materials; unlike any plane that has ever been seen in the sky by engineers of the Lilium Company in Munich Germany that operates near a life-size model of the company's 36 electric jet-powered vertical takeoff aircraft designed to carry a pilot and six passengers up to 250 kilometers. Many enterprises operate on the same electric aircraft. Some are self-sufficient and used in the nascent fields of regional and sky taxis. The Maverick's integrated wing aircraft design is an example of how the aerospace sector is "greening" ahead of other industries. Despite overcoming several technological obstacles, it might lower carbon emissions by 40% in 100 compared to the now in-use aircraft. The fundamental benefit of the streamlined form is that it acts like a wing throughout, which lowers resistance and facilitates lifting. Researchers at the Delft University of Technology in the Netherlands developed the Flying-V, an aircraft that resembles a boomerang very much, using the same design principles. When Airbus revealed last year that they were developing a model aircraft that would require 15 years of research and testing, they created a big sensation in the market. This model aircraft has one outstanding capability: it is zero-carbon aviation, similar to an electric automobile. Zero pollution does not always imply zero carbon emissions. Similar to how a car battery has to be charged, which involves considering the source of the power. Airbus' strategy raises the issue of how to produce and store hydrogen fuel; there is an additional difficulty, too. Liquid hydrogen, like that used in the US space program, must be super-compressed and kept at extremely low temperatures (below 253 degrees Celsius) in order to remain liquid, which clearly consumes a tremendous amount of energy. Hydrogen will occupy a sizable amount of space in an Aero plane if it is in a gaseous condition due to the fact that substantially larger fuel tanks would be required to provide the same propulsion as kerosene. In any event, a hydrogen-powered aircraft would be considerably unlike current planes, necessitating new infrastructure at the airport to support it. These barriers are accepted by Airbus. Nonetheless, there is still hope for the future. All above, it is clear from the information above that both Aero plane manufacturers and airlines are working hard to create aircraft that will contribute to the elimination of carbon dioxide emissions. Alternatively, there is a rise in the utilization of renewable energy, particularly since that new breakthroughs are being developed to do our part to protect the environment as much as we can.

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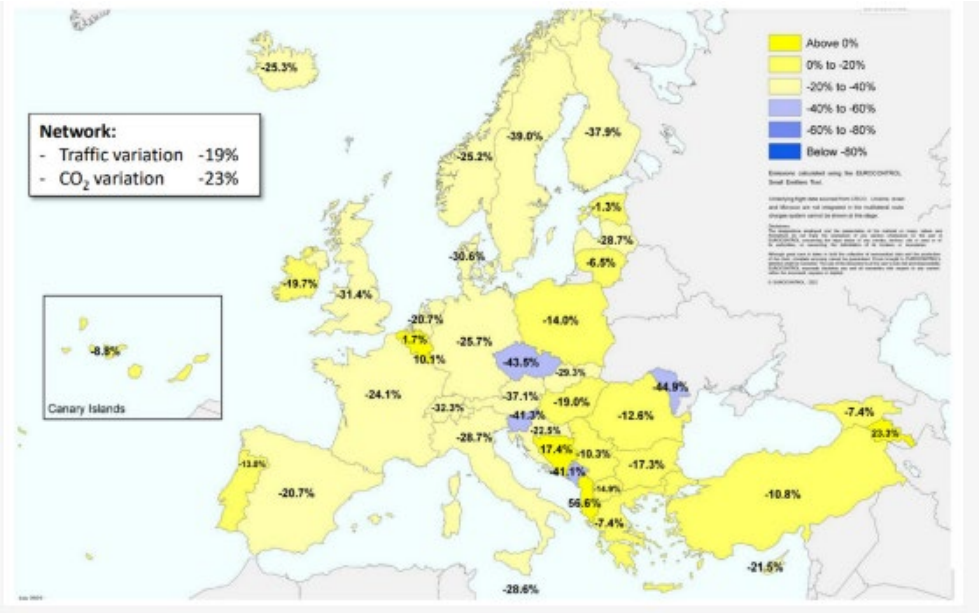

Figure 2: CO_2 variation from January to June 2022 vs. 2019 departures.
Source Reprinted with permission from EUROCONTROL (2022)

Aviation can also leverage lessons from the current pandemic to foster greater flexibility in terms of tickets and booking and provide a better customer experience in the manner most airlines accommodated passengers at the height of the pandemic. Such a move can be employed by airlines to address challenges imposed by extreme weather events whose impact on the aviation industry has been on the increase in recent years. The current labor challenges for the sector can be used to foster better working and wage conditions for the aviation industry and pace the rate at which the industry addresses the sustainability challenges it faces in line with the dictates of the Sustainable Development Goals agenda. Part of the challenges that the action faced at the height of the pandemic was severe liquidity challenges. Airlines, airport companies, and other stakeholders can take lessons and better prepare and push for increased cash reserves which will allow the airline to build better resilience should there be such catastrophic events in the future.

Conclusions and Scholars' Perspective

Current developments in the aviation sector are regarded as a crucial condition in the global aviation sector. Since the previous COVID-19 epidemic, airlines have faced challenges, particularly with regard to revenue, which has limited flights in various countries, preventing airlines from being able to fly 100% of the time in the past. There are also rising costs for the COVID-19 epidemic's prevention, including labor costs. The cost of leasing space or certain airlines' obligation to pay back debt taken on before the COVID-19 pandemic prevents them from making enough money to meet their expenditures. As a result, the airline had to lay off a large number of staff in order to reduce the cost burden as much as possible. Rather, it was not just these costs that drove up the price of oil to $120 a barrel on the global market. The primary expense that airlines are forced to endure is the price of fuel, which also drives up labor costs. Yet, collecting fuel surcharges for air travel or charging a fuel fee while raising prices is one way that airline corporations might save expenses. It is, nevertheless, impossible to raise prices too much due to increased market rivalry due to a variety of variables. In the midst of the epidemic, the number of recently established airlines has surged while the number of passengers has decreased by more than 70%.

In accordance with WHO norms, steps are taken to lower the risk of COVID-19 infection, including developing innovative ideas to improve passenger service. In addition, there is a rising concern for the environment, with organizations like ICAO and IATA working hard to limit greenhouse gases like carbon emissions, which are directly linked to global warming. The gathering of global leaders has taken place on multiple occasions to encourage the reduction of carbon emissions into the atmosphere. Being a huge business that consumes a lot of fuel every flight, the aviation sector is required

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to adapt by putting new technologies to use. In particular, aircraft makers must switch to more clean energy to limit the discharge of hazardous chemicals into the environment. To ensure the most reliable payment, the procedure begins with collecting money from gas-emitting aero planes through a middleman like IATA Aviation Carbon Exchange. Hence, starting this investment is a wise decision. The money will also be used to plant trees throughout the world as part of new developments. In order to receive discounts on purchases by developing innovations for the greatest efficiency and effectiveness, passengers must be aware of ways to minimize carbon emissions.

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