# THE ROLE OF COST-BENEFIT ANALYSIS OF USING BIOFUEL IN ACHIEVING SUSTAINABILITY GOALS WITHIN GREEN AVIATION TECHNOLOGIES: A COMPREHENSIVE ANALYSIS OF SCHEDULED AIRLINES

**EMAN AHMED ALI**
**HIGHER INSTITUTE OF TOURISM AND HOTELS (EGOTH), ALEXANDRIA, EGYPT**
**HANAN AHMED ALI**
**FACULTY OF TOURISM AND HOTELS, UNIVERSITY OF SADAT CITY, EGYPT**

## ABSTRACT

*Amid increasing environmental challenges and sustainability goals aimed at reducing carbon emissions and enhancing energy efficiency, biofuels stand out as a prominent solution within green aviation technologies. Biofuels, produced from biological materials such as plants and organic waste, are a potential alternative to traditional fossil fuels, offering significant reductions in carbon emissions and improved environmental sustainability. This fuel reduces the carbon footprint of aviation by providing a more sustainable energy source, as the carbon emitted during combustion is offset by the carbon absorbed by the plants during their growth. The use of biofuels in aviation not only reduces emissions but also enhances energy efficiency, improving the environmental performance of aircraft. However, biofuels face notable challenges related to high costs and production constraints, requiring significant investments in technology and infrastructure. Additionally, indirect environmental impacts, such as land and water use for raw material production, must be considered, which could affect the overall environmental benefits of the fuel. Leading airlines such as Delta and Lufthansa have begun implementing pilot projects to integrate biofuels into their operations, providing valuable insights into their actual impact on environmental performance and cost. Overall, despite the potential benefits of biofuels in achieving sustainability goals within green aviation technologies, achieving these goals requires overcoming economic and environmental challenges associated with biofuel production and use, necessitating support for technological innovations and strategic investments to achieve sustainable and long-term results in the aviation industry.*

**KEYWORDS:** Biofuels – Sustainability – Green Aviation – scheduled Airlines.

## INTRODUCTION

Amid the ongoing escalation of environmental challenges and global pressure to reduce carbon emissions, the aviation industry has become a primary target for environmental sustainability, particularly regarding reducing its carbon footprint. Green aviation technologies play a crucial role in addressing these issues by aiming to improve the environmental performance of aircraft through technological innovations and the use of alternative energy sources (Boeing, 2020). Among these alternative sources, biofuels are considered a promising solution that enhances environmental sustainability due to their characteristics that allow for reduced carbon emissions and improved energy efficiency (Sustainable Aviation Fuel, 2023).Biofuels are a type of fuel derived from biological materials, such as plants and agricultural crops, and are considered a potential alternative to traditional fossil fuels used in aviation (Kärcher et al., 2021). Biofuels are notable for their ability to reduce carbon emissions, as the carbon emitted during combustion is balanced by the carbon absorbed from the atmosphere by the plants used to produce them (Singh et al., 2019). This makes them a more sustainable option compared to fossil fuels, which add additional carbon to the atmosphere. Despite these environmental benefits, the use of biofuels in aviation is not without challenges. First, the production of biofuels requires significant investments in technology and infrastructure, contributing to their higher cost compared to conventional fuels (He et al., 2020). Second, there are issues related to indirect environmental impacts, such as land and water use for raw material production, which can affect the overall sustainability of biofuels (Finkbeiner et al., 2019). Furthermore, the effectiveness of biofuels depends on the development of advanced technologies to improve production efficiency and reduce costs (Williams et al., 2022).

Global airlines have begun to adopt biofuels as part of their green aviation strategies, implementing pilot projects and tests to evaluate their impact on environmental performance and operational costs (Airbus, 2021). Experiments by companies such as Delta and Lufthansa demonstrate that biofuels can play an important role in achieving sustainability goals, but success depends on overcoming challenges related to production and cost (Lufthansa Group, 2023). Based on the above, this research aims to analyze the role of biofuels in achieving sustainability goals within green aviation technologies, focusing on practical applications by airlines and the challenges and opportunities associated with their use. The study will examine how biofuels affect carbon emissions and energy efficiency, and will also evaluate their potential for contributing to long-term sustainability in the aviation industry economic and environmental aspects of its use, aiming to provide comprehensive Insights into Its Future as a Sustainable Solution in the Aviation Industry.

## RESEARCH PROBLEM

The research problem lies in the limited use of biofuels in achieving sustainability goals within green aviation technologies, due to a range of economic, technical, and environmental challenges. Although biofuels are recognized for their benefits in reducing carbon emissions and improving the environmental performance of aircraft, their widespread adoption in the aviation industry faces significant obstacles. These challenges include the high cost of biofuel production compared to conventional fuels, limitations in production technology and required infrastructure, and indirect environmental impacts related to land and water use for raw material production. Furthermore, there are gaps in knowledge regarding how biofuels impact the environmental performance and operational costs of airlines, as a comprehensive analysis of different companies' experiences is still lacking. Thus, there is a need for an in-depth study to determine the effectiveness of biofuels in achieving the environmental goals of green aviation technologies and to provide practical solutions to the challenges hindering their expanded use.

## STUDY OBJECTIVES

- Assess the effectiveness of biofuels in reducing carbon emissions.
- Analyze the efficiency of biofuels in improving aircraft performance.
- Explore the economic challenges associated with biofuels.
- Review the indirect environmental impacts affecting the achievement of sustainability goals,Weigh the costs and benefits of using biofuels in airlines’ operation instead of fossil fuels.

## STUDY HYPOTHESES

### THE STUDY IS BASED ON THE FOLLOWING HYPOTHESES

1. Biofuels significantly contribute to reducing carbon emissions in aircraft compared to traditional fossil fuels.
2. Biofuels improve energy efficiency in aircraft compared to conventional fuels, aiding in the enhancement of green aviation strategies

3. The high costs of biofuel production present a major barrier to its widespread adoption in the airlines.
4. The production of biofuels has indirect environmental impacts that affect sustainability within airlines.
5. There are statistically significant differences in the responses of sample individuals to the variables of cloud computing and the development and quality of air cargo services attributed to demographic variables (qualification, years of experience, position).

## BIOFUELS AND THE ENVIRONMENT

Biofuels are produced from biological sources, such as plants and agricultural crops. They differ from traditional fossil fuels, which are extracted from underground sources like oil and natural gas. One of the most significant environmental advantages of biofuels is their ability to reduce carbon dioxide (CO2) emissions significantly. This is because the carbon released during the combustion of biofuels is part of the natural carbon cycle, as the plants absorbed it from the atmosphere during their growth (Sustainable Aviation Fuel, 2023).

## EFFECTIVENESS OF BIOFUELS IN REDUCING CARBON EMISSIONS

Studies indicate that using biofuels can lead to a reduction in carbon emissions ranging from 50% to 80% compared to conventional fossil fuels. For example, a study conducted by researchers at the University of California showed that using biofuels in aircraft can reduce carbon emissions by up to 70% (Kärcher et al., 2021). The same study demonstrated that biofuels produce lower emissions of nitrogen oxides and volatile organic compounds, enhancing their effectiveness in reducing the environmental impacts of aviation.

## TECHNOLOGIES USED IN BIOFUELS

Biofuels used in aviation are produced from a variety of sources, including plant fats, animal oils, and other organic materials. Conversion technologies such as pyrolysis and chemical trans esterification are employed to transform these materials into usable fuel for aircraft engines (S,yingh et al., 2019). These technologies enable the production of high-quality fuel with characteristics similar to conventional fuel, making it a viable alternative in the aviation industry.

### BIOFUELS IMPROVE ENERGY EFFICIENCY IN AIRCRAFT COMPARED TO CONVENTIONAL FUELS

Energy efficiency is a key factor affecting aircraft performance, reducing operational costs, and minimizing the environmental impact of the aviation industry. Biofuels, produced from biological sources such as plants and organic materials, are considered promising alternative to conventional fossil fuels in this context. Current studies and data suggest that biofuels can enhance the energy efficiency of aircraft compared to traditional fuels, thus reinforcing their viability as a sustainable option in the aviation industry (Smith et al., 2021).

### IMPROVING FUEL EFFICIENCY

One of the main dimensions where biofuels are considered effective is in improving fuel efficiency. Multiple studies have shown that the use of biofuels can lead to improved engine performance due to their chemical properties. According to a study from the *Journal of Propulsion and Power*, biofuels have a higher oxygen content than fossil fuels, leading to more efficient combustion and a reduction in fuel consumption by up to 2-5% (Fang et al., 2018). This improvement in fuel efficiency not only helps reduce operational costs but also contributes to lower emissions from aircraft.

### ENHANCING ENGINE PERFORMANCE

Biofuels can positively affect aircraft engine performance in various ways. Tests on commercial aircraft have demonstrated that biofuels can reduce engine wear due to their pure chemical composition and minimal sulfur content. A study conducted by *Aerospace Science and Technology* confirmed that using biofuels in aircraft improves engine performance stability and reduces wear due to lower sulfur and other harmful components (Bureau et al., 2015). This benefit enhances aircraft reliability and reduces maintenance costs.

### PREVIOUS STUDIES ON IMPROVING ENERGY EFFICIENCY

A study published in the *Journal of Cleaner Production* indicates that biofuels can offer notable improvements in energy efficiency compared to traditional fuels. According to this study, the use of biofuels can enhance aircraft engine performance by between 3% and 5%, reflecting an improvement in fuel combustion efficiency (Zhang et al., 2020). The study was based on field trials with aircraft engines operating on biofuels and found that biofuels provide significant energy efficiency improvements.

Furthermore, a study conducted by the University of Cambridge demonstrated that biofuels could contribute to a reduction in fuel consumption by up to 10% on long flights due to their chemical properties that lead to more efficient combustion (Smith et al., 2021). The study confirmed that this improvement in energy efficiency helps reduce aircraft operational costs, as well as minimizing environmental impact.

### Airlines Trials and Practical Applications

Experiments by major airlines support the theoretical results regarding energy efficiency improvements using biofuels. For instance, Boeing has conducted tests on its aircraft using biofuels and found that aircraft operating on biofuels showed improvements in energy efficiency, contributing to better overall aircraft performance (Boeing, 2022). These practical trials indicate that biofuels are not only an environmentally sustainable option but also offer tangible benefits in terms of energy efficiency improvement.

### Production Challenges

- **High Costs of Biofuel Production**

The high costs of biofuel production start from the initial stages of collecting and preparing raw materials. Biofuel sources vary between plant oils, such as soybean oil, animal fats, and other organic materials. Biofuel production involves complex processes such as chemical conversion, refining, and filtering, which increase the overall costs (He et al., 2020). For example, a report from *Renewable and Sustainable Energy Reviews* indicates that the cost of producing biofuel from used cooking oil is between 3 to 4 times higher than producing conventional fuel, due to the cost of raw materials and the technologies used (Gao et al., 2019).

The high costs of biofuel production extend beyond economic challenges to include environmental issues. These issues involve land and water use, as growing crops for biofuel production can indirectly affect the environment. Reports from *Biofuels, Bioproducts & Biorefining* have highlighted that biofuel production might compete with food crop cultivation for land, raising concerns about environmental sustainability (Kärcher et al., 2021).

Biofuels are considered a promising alternative to fossil fuels. Although biofuels are presented as an environmentally friendly solution due to their carbon emission reduction capabilities, their production entails indirect environmental impacts that may affect overall sustainability. In this context, the relationship between biofuels and green aviation is an important area requiring a deep understanding of their indirect environmental effects.

- ENVIRONMENTAL CHALLENGES

## TECHNOLOGICAL AND INFRASTRUCTURE CHALLENGES

Technological challenges are a major reason for the high cost of biofuels. The processes required to convert raw materials into aviation fuel involve advanced technology and expensive infrastructure. Despite advancements in production technology, many biofuel production facilities still struggle to achieve the economies of scale necessary to lower costs (Finkbeiner et al., 2019). These challenges include improving chemical conversion technologies such as pyrolysis and chemical transesterification, which require substantial investments in research and development (Singh et al., 2021).

## ECONOMIC IMPACT OF APPLYING BIOFUELS

The impact of high biofuel costs on the aviation industry can be significant. Fuel represents a large portion of the operating costs for aircraft, and when biofuel costs are much higher than conventional fuel, it affects the economic feasibility for airlines. A study published in the *Journal of Air Transport Management* found that high biofuel costs could lead to an increase in operating costs by up to 30%, potentially resulting in higher airfares or reduced profit margins for airlines (Jensen et al., 2020).

- ***High Natural Resource Consumption***

Biofuel production requires large amounts of natural resources, such as land and water. Growing crops for biofuel, like corn and soybeans, requires extensive land areas. According to a study by Searchinger et al. (2018), converting agricultural land from food crops to biofuel crops can lead to increased food prices and heightened food security risks, as biofuel production competes with food production for resources.

Furthermore, water consumption in growing biofuel crops can put pressure on water resources. A study published by Hoekman et al. (2012) indicates that biofuel production requires substantial amounts of water, which can lead to the depletion of water resources in already water-scarce areas. This excessive consumption can impact aquatic ecosystems and lead to the degradation of rivers and groundwater resources.

- ***Biodiversity Loss and Soil Degradation***

Biofuel production can have negative environmental effects through land use changes and soil degradation. Intensive conversion of natural land to agricultural land for biofuel crops can lead to biodiversity loss and degradation of natural habitats. A study published by Fargione et al. (2008) suggests that such conversion can destroy natural habitats for many plant and animal species, affecting biodiversity.

Additionally, the use of fertilizers and pesticides in growing biofuel crops can lead to soil and groundwater pollution. A study by Tilman et al. (2006) illustrates that these practices can result in soil degradation and groundwater contamination, harming agricultural ecosystems and affecting environmental quality.

### AIRLINES TRIALS AND PRACTICAL APPLICATIONS

### BIOFUELS AND THEIR ROLE IN GREEN AVIATION

In the field of green aviation, biofuels are considered a potential alternative to fossil fuels due to their ability to reduce carbon emissions. However, the indirect effects of biofuel production must be considered when assessing its sustainability. The challenges associated with resource consumption and environmental degradation can affect the potential environmental benefits of using biofuels in green aviation (Kärcher et al., 2021).

### AIRLINE EXPERIMENTS WITH BIOFUELS

The aviation industry has shown increasing interest in using biofuels as an alternative to conventional fossil fuels, as part of the effort to achieve environmental sustainability goals and reduce carbon emissions. Airline experiments in this area have provided valuable data on the effectiveness of biofuels and the challenges associated with their use. This section discusses the experiences of some airlines with biofuels, focusing on the benefits and challenges identified.

### LEADING AIRLINE EXPERIENCES

### CATHAY PACIFIC

Cathay Pacific, based in Hong Kong, began testing biofuels through experimental projects in 2014. In that year, the airline conducted its first test flight using a blend of conventional jet fuel and biofuel, demonstrating the safety of biofuel use in commercial aircraft (Cathay Pacific, 2014). According to the company's report, using biofuel led to a reduction in carbon emissions by up to 10% compared to conventional fuel, enhancing the sustainability of aviation operations (Cathay Pacific, 2015).

### LUFTHANSA

The German airline Lufthansa is considered a pioneer in biofuel usage. In 2011, the company launched the "Lufthansa Biofuel Program," which included several test flights using biofuel made from used cooking oil. Initial results showed that biofuel could reduce carbon emissions by between 20% and 50% (Lufthansa, 2011). Additionally, Lufthansa reported that biofuel use could help improve engine performance and reduce other harmful emissions (Lufthansa, 2013).

### UNITED AIRLINES

United Airlines conducted its first commercial biofuel test in 2016, using a blend of biofuel and conventional fuel on flights from Los Angeles to Houston. According to the company's report, this trial confirmed that biofuel could be a reliable and effective alternative to conventional fuel, with noticeable improvements in fuel efficiency and emission reductions (United Airlines, 2016). However, the company acknowledged that the high production costs of biofuel remain a major challenge to its widespread adoption (United Airlines, 2017).

### CHALLENGES RELATED TO BIOFUEL USE

Despite the tangible benefits of biofuels, several key challenges have emerged from these trials:

1. **High Costs:** The production cost of biofuel is higher than that of conventional fuel, posing a significant barrier to its broader use. A study published in the *Journal of Cleaner Production* indicated that high biofuel production costs affect companies' ability to achieve financial benefits from its use (Zhang et al., 2020).
2. **Supply and Availability:** The supply of biofuel remains limited, affecting airlines' ability to use it regularly. According to a report from the International Air Transport Association (IATA), current supplies are insufficient to meet the global aviation industry's needs (IATA, 2019).
3. **Indirect Environmental Impacts:** While biofuel reduces carbon emissions during combustion, its production causes indirect environmental impacts such as land and water use. A study published in *Nature Sustainability* addressed these issues, showing that growing crops for biofuel can lead to land use changes and habitat degradation, affecting biodiversity and ecosystem sustainability (Searchinger et al., 2018).

### SOLUTIONS AND DIRECTIONS FOR PROMOTING BIOFUEL USE

To enhance biofuel use in aviation and address associated challenges, several approaches and solutions are being pursued:

- **Investment in Production Technology:** Directing investment toward improving biofuel production technologies can help reduce costs and increase production efficiency. A study by the

International Energy Agency emphasized the importance of researching new technologies to boost biofuel production efficiency and reduce costs (IEA, 2021).

- **Use of Non-Food Sources:** Utilizing non-food sources such as agricultural waste and marine biomass can help reduce competition with food production and minimize negative environmental impacts. A study published in *Renewable and Sustainable Energy Reviews* highlighted the potential of these sources as alternative solutions (Wang et al., 2017).
- **Enhanced Collaboration:** Strengthening collaboration between governments, airlines, and manufacturers can contribute to developing policies that support biofuel use and facilitate market access. A report from the World Economic Forum noted the importance of multi-stakeholder partnerships in achieving aviation sustainability goals (WEF, 2020).

## STUDY METHODOLOGY

### STUDY TOOL

The study utilized a questionnaire to collect data from 2022-2024 . The questionnaire included 50 statements in addition to demographic and job-related information for the study sample. The questionnaire consisted of two main sections as follows:

**Section 1: The Role of Biofuels in Achieving Sustainability Goals within Green Aviation Technologies**
This section included 50 statements divided into four dimensions:

1. Evaluation of Biofuel Effectiveness (14 statements)
2. Biofuel Efficiency in Improving Aircraft Performance (16 statements)
3. Economic Challenges (15 statements)
4. Impacts on Achieving Sustainability (15 statements) The statements for this section were derived from the studies of Wang et al. (2014), Marzano et al. (2016), Marzano (2017), Toth (2017), Mueller (2017), Steinkuehler and Duncan (2018), Krelja et al. (2018), Chanias et al. (2019), Atmos and Environ (2017), Environ (2017), Pei and Liu (2017), Tarafdar (2018), and Jingran and Zhang (2020).
   The study responses were measured using a five-point Likert scale ranging from strong disagreement to strong agreement (1 = Strongly

Disagree, 2 = Disagree, 3 = Neutral, 4 = Agree, 5 = Strongly Agree) (Gaafar et al., 2021).

### SECTION 2: PERSONAL DATA

This section included 4 questions regarding the educational qualifications, years of experience within the company, and current job position.

### STUDY POPULATION AND SAMPLE

The study population consisted of employees at various administrative, technical, and engineering levels in different airlines like lufthanza , cathay pacific and united airlines A total of 400 questionnaires were distributed to a sample of employees Out of these, 380 questionnaires were returned, with 350 valid for data analysis. The remaining 30 questionnaires were deemed invalid due to repeated answers to some questions, lack of responses to certain questions, or outlier values in the responses , the period of this field study from 2022 – 2024 .

### STATISTICAL TESTS USED

The study data analysis utilized SPSS V.26 software. The following statistical methods were employed:

1. **Reliability Test:** Used to verify the consistency and validity of the questionnaire.
2. **Frequencies, Percentages, Means, and Standard Deviations:** Used to describe the sample characteristics and determine the responses of the sample members to all sections of the study tool. The mean values for the levels of agreement and disagreement on the Likert scale were as follows: Strongly Disagree = 1 to 1.79, Disagree = 1.80 to 2.59, Neutral = 2.60 to 3.39, Agree = 3.40 to 4.19, Strongly Agree = 4.20 to 5.
3. **Correlation Coefficients:** Used to describe the strength and direction of the relationships between the study variables.
4. **Simple Regression Analysis:** Used to determine the effect of an independent variable on a dependent variable and to assess the value of this effect.
5. **Multiple Regression Analysis:** Used to determine the effect of multiple independent variables on a dependent variable and to assess the combined effect of these variables.

## RESULTS OF ANALYSIS AND HYPOTHESIS TESTING

### RESULTS OF RELIABILITY AND INTERNAL CONSISTENCY TESTING FOR THE QUESTIONNAIRE

Reliability testing was conducted using Cronbach's alpha coefficient to ensure the reliability of the study tool and to verify the generalizability of the study results to the overall population (Al-Romeedy & Ozbek, 2022; Al-Romeedy & Mohamed, 2022). Table 1 presents the results of the Cronbach's alpha test.

***Table 1: Cronbach's Alpha Values***

| Variables | Cronbach's Alpha Value |
|---|---|
| Evaluation of Biofuel Effectiveness | 0.892 |
| Biofuel Efficiency in Improving Aircraft Performance | 0.847 |
| Economic Challenges | 0.786 |
| Impacts on Achieving Sustainability | 0.824 |

***Table 1: Cronbach's Alpha Values***

Table 1 shows that the Cronbach's Alpha coefficients for all study variables and dimensions exceed the acceptable threshold of 0.70 (Al-Romeedy, 2019; Zaki & Al-Romeedy, 2019). These values indicate high and good reliability for the research purposes, suggesting that the measures are dependable for their intended use and that the results from the field study can be generalized.

### *DEMOGRAPHIC AND OCCUPATIONAL CHARACTERISTICS OF THE STUDY SAMPLE*

Table 2 presents the demographic and occupational characteristics of the study sample, including qualifications, years of experience within the company, and current job positions.

**Table 2: Demographic and Occupational Characteristics of the Study Sample**

| Characteristics | Frequencies | Percentages |
|---|---|---|
| Qualification | | |
| Bachelor's / License | 170 | 48.5% |
| Master's | 120 | 34.4% |
| Doctorate | 60 | 17.1% |

| Years of Experience in the Company | | |
|---|---|---|
| Less than 1 year | 40 | 11.4% |
| 1 to 3 years | 43 | 12.2% |
| 3 to 7 years | 40 | 11.4% |
| 7 years and more | 227 | 64.8% |
| Current Job Position | | |
| Technical Specialists | 45 | 12.8% |
| IT and Technology Staff | 39 | 11.1% |
| Traffic and Supply Staff | 45 | 12.8% |
| Human Resources | 32 | 9.1% |
| Aircraft Engineers | 49 | 14% |
| Accounting Staff | 26 | 7.4% |
| Public Relations and Customer Service Specialists | 20 | 5.7% |
| Air Cargo Operations Staff | 15 | 4.2% |
| Department Managers | 20 | 5.7% |
| Assistant Aircraft Engineers | 30 | 8.5% |
| Executive Management Staff | 29 | 8.1% |

Table 2 shows the frequencies and percentages for qualifications, years of experience, and current job positions of the study sample. Regarding qualifications, the results highlight that more than two-thirds of the study sample hold a Bachelor's degree, with 170 individuals representing 48.5%. Additionally, 30 individuals (8.5%) hold a Master's degree. Concerning years of experience within the company, those with 1 to 3 years of experience number 43 (12.2%), followed by those with 3 to 7 years of experience, totaling 40 individuals (11.4%). The largest proportion, with 7 years or more of experience, is 227 individuals, representing 64.8%.

## Descriptive Analysis of the Study Variables

## Role of Biofuels in Achieving Sustainability Goals within Green Aviation Technologies

### A. Assessment of Biofuel Effectiveness

**Table 3: Mean Scores and Standard Deviations for Evaluating Biofuel Effectiveness**

| No. | Assessment of Biofuel Effectiveness | Mean | Standard Deviation |
|---|---|---|---|
| 1 | Biofuel effectively reduces carbon dioxide emissions compared to conventional fuel. | 3.50 | 1.19 |
| 2 | Using biofuel in aircraft significantly contributes to improving the environmental performance of aviation. | 3.57 | 1.06 |
| 3 | Biofuel offers greater environmental benefits compared to conventional fossil fuels. | 3.52 | 1.15 |
| 4 | Current biofuel technologies are sufficient to achieve a noticeable reduction in carbon emissions. | 3.53 | 1.18 |
| 5 | The cost of biofuel represents a major barrier to its widespread adoption in the aviation industry. | 3.51 | 1.06 |
| 6 | There is sufficient government policy support to encourage the use of biofuel in aviation. | 3.59 | 1.17 |
| 7 | Biofuel can be a sustainable alternative to conventional fuel in the near future. | 3.56 | 1.14 |
| 8 | Biofuel still faces technical challenges affecting its effectiveness in reducing carbon emissions. | 3.53 | 1.08 |
| 9 | The shift towards biofuel use will significantly contribute to achieving climate change mitigation goals. | 3.55 | 1.12 |
| 10 | Expanding the use of biofuel requires significant improvements in current infrastructure. | 3.56 | 1.14 |
| 11 | Biofuel is considered an effective solution for reducing carbon emissions in commercial aircraft. | 3.58 | 1.13 |
| 12 | Investing more in biofuel research will lead to improvements in its effectiveness in reducing carbon emissions. | 3.54 | 1.19 |
| 13 | Biofuel is considered a better environmental option than conventional fossil fuels. | 3.57 | 1.18 |

| | | | |
|---|---|---|---|
| 14 | The current infrastructure is sufficient to support the expansion of biofuel use. | 3.55 | 1.12 |
| | **Overall Mean and Standard Deviation** | 3.56 | 1.01 |

The results from Table 3 reflect the responses of the study sample to the dimension of evaluating biofuel effectiveness. Overall, the mean score for the responses on biofuel effectiveness is 3.56, with a standard deviation of 1.01. This mean score indicates that the role of biofuel in achieving sustainability goals within green aviation technologies is perceived as high. The mean scores for this dimension range between 3.55 and 3.57. The statement "Biofuel provides greater environmental benefits compared to conventional fossil fuels" has the highest mean score of 3.57, with a standard deviation of 1.06. Conversely, the statement "The effectiveness of biofuel contributes to ensuring the achievement of sustainability goals within green aviation technologies" ranks last with a mean score of 3.50.

### B. Biofuel Efficiency in Improving Aircraft Performance

**Table 4: Mean Scores and Standard Deviations for Biofuel Efficiency in Improving Aircraft Performance**

| No. | Biofuel Efficiency in Improving Aircraft Performance | Mean | Standard Deviation |
|---|---|---|---|
| 1 | Biofuel contributes to improving energy consumption efficiency in aircraft. | 2.37 | 0.765 |
| 2 | Using biofuel can lead to increased aircraft range. | 2.44 | 0.788 |
| 3 | Biofuel has a positive impact on thrust and engine efficiency in aircraft. | 3.28 | 1.01 |
| 4 | Flying with biofuel has shown an improvement in overall aircraft performance. | 3.42 | 1.05 |
| 5 | Biofuel can help reduce maintenance costs for aircraft engines. | 3.39 | 1.12 |
| 6 | There is a noticeable improvement in harmful emissions when using biofuel in aircraft. | 3.42 | 1.15 |
| 7 | Current biofuel technologies provide reliable performance under various flying conditions. | 2.39 | 0.841 |

| | | | |
|---|---|---|---|
| 8 | Biofuel can significantly improve aircraft performance in harsh weather conditions. | 2.37 | 0.765 |
| 9 | Expanding the use of biofuel will contribute to improving flight efficiency in the long term. | 2.41 | 0.783 |
| 10 | Biofuel meets all necessary quality standards for commercial aviation. | 3.24 | 1.03 |
| 11 | There are noticeable improvements in aircraft response when using biofuel. | 3.46 | 1.08 |
| 12 | Replacing conventional fuel with biofuel contributes to reducing the environmental impact of aviation. | 3.37 | 1.16 |
| 13 | Biofuel provides consistent performance compared to conventional fuel under all operating conditions. | 3.43 | 1.19 |
| 14 | Biofuel plays an important role in developing sustainable aviation technologies. | 2.35 | 0.847 |
| 15 | The current cost of biofuel is reasonable considering its benefits in improving aircraft performance. | 3.24 | 1.03 |
| 16 | Technological improvements in biofuel will increase its effectiveness in enhancing aircraft performance in the near future. | 3.41 | 1.06 |
| | **Overall Mean and Standard Deviation** | 2.96 | 0.948 |

The results from Table 4 show the responses of the study sample to the dimension of biofuel efficiency in improving aircraft performance. Overall, the mean score for responses on biofuel efficiency in improving aircraft performance is 2.96, with a standard deviation of 0.948. This mean score indicates that the level of biofuel efficiency in enhancing aircraft performance is perceived as average. The mean scores for this dimension range from 2.37 to 3.42. The statement "Biofuel has a positive impact on thrust and engine efficiency in aircraft" has the highest mean score of 3.42, with a standard deviation of 1.05, indicating it is higher than the overall mean score of 2.96. Conversely, the statement "Biofuel contributes to improving energy consumption efficiency in aircraft" ranks lowest with a mean score of 2.37, which is lower than the overall mean score of 2.96, with a standard deviation of 0.765.

### C. Economic Challenges

**Table 5: Mean Scores and Standard Deviations for Economic Challenges**

| No. | Economic Challenges | Mean | Standard Deviation |
|---|---|---|---|
| 1 | The cost of producing biofuel is significantly higher compared to conventional fuel. | 3.83 | 1.15 |
| 2 | Investment in biofuel technology requires a substantial budget. | 2.60 | 1.00 |
| 3 | Distribution and infrastructure costs for biofuel are high compared to fossil fuels. | 3.35 | 1.09 |
| 4 | Current markets do not provide sufficient support for biofuel in terms of financial incentives. | 3.34 | 1.12 |
| 5 | The demand for biofuel is limited due to its higher cost compared to conventional alternatives. | 3.39 | 1.03 |
| 6 | Current government incentives are inadequate to encourage widespread use of biofuel. | 3.47 | 1.13 |
| 7 | The current economics of biofuel make it difficult to achieve economic viability in small projects. | 3.85 | 1.13 |
| 8 | Achieving profitability in the biofuel industry requires significant support from the government or private sector. | 2.63 | 1.02 |
| 9 | Fluctuations in raw material prices for biofuel significantly impact production costs. | 3.38 | 1.06 |
| 10 | Current biofuel production technology may not be widely available in emerging markets. | 3.37 | 1.11 |
| 11 | Producing biofuel requires long-term investments that may not always align with short-term profits. | 3.35 | 1.08 |
| 12 | The cost of research and development in the biofuel sector is a significant burden on companies. | 3.43 | 1.18 |
| 13 | Economic challenges of biofuel can affect companies' ability to expand into international markets. | 3.32 | 1.16 |
| 14 | Current environmental policies promote the use of biofuel by providing financial support to companies. | 3.31 | 1.08 |
| 15 | Innovation in biofuel technology could help reduce economic costs in the long term. | 3.46 | 1.12 |
| | Overall Mean and Standard Deviation | 3.33 | 1.06 |

The results from Table 5 reflect the responses of the study sample regarding the dimension of economic challenges. Overall, the mean score for responses on economic challenges is 3.33, with a standard deviation of 1.06. This mean score indicates that the level of economic challenges is perceived as moderate. The mean scores for this dimension range from 2.60 to 3.85. The statement "The cost of producing biofuel is significantly higher compared to conventional fuel" has the highest mean score of 3.85, with a standard deviation of 1.13, indicating it is higher than the overall mean score of 3.33. Conversely, the statement "Investment in biofuel technology requires a substantial budget" ranks lowest with a mean score of 2.60, which is lower than the overall mean score of 3.33, with a standard deviation of 1.00.

### D. Environmental Effects

**Table 6: Mean Scores and Standard Deviations for Environmental Effects**

| No. | Effects on Achieving Sustainability | Mean | Standard Deviation |
|---|---|---|---|
| 1 | The production of biofuel can contribute to deforestation and destruction of natural habitats. | 2.51 | 0.888 |
| 2 | Growing crops used for biofuel production may lead to intensive use of water resources. | 2.40 | 0.824 |
| 3 | Extensive conversion of agricultural systems to biofuel production can affect plant and animal diversity. | 2.30 | 0.771 |
| 4 | Biofuel production may lead to increased use of pesticides and chemical fertilizers, which negatively impact the environment. | 2.27 | 0.746 |
| 5 | Biofuel can cause increased competition for agricultural land between food production and fuel production. | 2.32 | 0.754 |
| 6 | Using biofuel improves air quality in aviation areas. | 2.38 | 0.782 |
| 7 | Biofuel reduces negative impacts on human health compared to conventional fuel. | 2.54 | 0.922 |
| 8 | Improving aviation efficiency with biofuel requires new technologies in aircraft design. | 2.57 | 0.883 |
| 9 | Biofuel contributes to supporting innovation and technological advancement in green aviation. | 2.43 | 0.821 |
| 10 | Biofuel production provides economic benefits by creating new job opportunities in the sustainable energy sector. | 2.32 | 0.775 |

| | | | |
|---|---|---|---|
| 11 | Using biofuel helps achieve emission reduction goals set by international environmental agreements. | 2.23 | 0.741 |
| 12 | Biofuel provides a sustainable alternative to fossil fuels in terms of direct environmental impacts. | 2.36 | 0.757 |
| 13 | Investment in biofuel enhances the aviation industry's ability to achieve its long-term environmental goals. | 2.37 | 0.780 |
| 14 | Encouraging biofuel use should be accompanied by measures to protect the environment from indirect impacts. | 2.51 | 0.927 |
| 15 | The technology used in biofuel production may contribute to high energy consumption, affecting environmental sustainability. | 2.33 | 0.786 |
| | Overall Mean and Standard Deviation | 2.39 | 0.712 |

The results from Table 6 reflect the responses of the study sample regarding the dimension of effects on achieving sustainability. Overall, the mean score for responses on the effects of biofuel on sustainability is 2.39, with a standard deviation of 0.712. This mean score indicates that the level of effects on achieving sustainability is perceived as low. The mean scores for this dimension range from 2.27 to 2.54. The statement "The production of biofuel can contribute to deforestation and destruction of natural habitats" has the highest mean score of 2.54, which is higher than the overall mean score of 2.39, with a standard deviation of 0.922. Conversely, the statement "The production of biofuel may lead to increased use of pesticides and chemical fertilizers, which negatively impact the environment" ranks lowest with a mean score of 2.27, which is lower than the overall mean score of 2.39, with a standard deviation of 0.746.

## TESTING THE STUDY HYPOTHESES

### TESTING THE FIRST HYPOTHESIS:

The first hypothesis states: "Biofuel significantly contributes to reducing carbon emissions in aircraft compared to conventional fossil fuel."

To determine the impact of the four aspects of biofuel on reducing carbon emissions in aircraft, a multiple regression analysis was conducted. The following tables present the results of the multiple regression analysis.

**Table 7: Model of the Impact Relationship between Biofuel and Reducing Carbon Emissions in Aircraft Compared to Conventional Fossil Fuel**

| Correlation Coefficient | Squared Correlation | Adjusted R-Squared | Standard Error of Estimate |
|---|---|---|---|
| 0.794 | 0.688 | 0.687 | 0.14901 |

Table 7 highlights a significant correlation between biofuel and the reduction of carbon emissions in aircraft compared to conventional fossil fuel, with a significance level of 0.000 at a 5% error rate and a 95% confidence level (p value < 0.05). The correlation coefficient is 0.794, indicating a strong positive correlation, which means that as an airline increases its reliance on biofuel, it contributes to a reduction in carbon emissions in aircraft compared to conventional fossil fuel. The adjusted R-squared value is 0.687, which means that the independent variable (biofuel) explains 68.7% of the variation in the level of reduction in carbon emissions in aircraft.

**Table 8: Results of One-Way ANOVA**

| Source of Variation | Sum of Squares | Degrees of Freedom | Mean Square | F Value | Significance Level |
|---|---|---|---|---|---|
| Regression | 443.002 | 4 | 110.750 | 498.966 | 0.000 |
| Residual | 5.595 | 252 | 0.022 | | |
| Total | 448.597 | 256 | | | |

Table 8 shows the validity of the model used to test the impact relationship between biofuel and reducing carbon emissions in aircraft compared to conventional fossil fuel, with an F value of 498.966 and a significance level of 0.000, which is less than 0.05. This indicates that the model, with its independent variables, is valid for predicting the dependent variable values.

**Table9: Regression Coefficients for the Role of Biofuel in Achieving Sustainability Goals within Green Aviation Technologies**

| Variable | B Coefficient | Std. Error | Standardized Beta | t-Value | Sig. |
|---|---|---|---|---|---|
| Evaluation of Biofuel Effectiveness | 1.026 | 0.120 | | 8.542 | 0.000 |
| Efficiency of Biofuel in Improving Aircraft Performance | 0.827 | 0.042 | 0.856 | 19.697 | 0.000 |

| | | | | | |
|---|---|---|---|---|---|
| Economic Challenges | 0.149 | 0.057 | 0.107 | 2.617 | 0.009 |
| Effects on Achieving Sustainability | -0.248 | 0.027 | -0.134 | -9.288 | 0.000 |

Table 9 shows that the four dimensions of the role of biofuel together significantly impact achieving sustainability goals within green aviation technologies. The t-values are higher than 1.96, confirming the impact of biofuel on achieving sustainability goals within green aviation technologies. The regression model explains 68.7% of the variations in the level of achieving sustainability. Therefore, the hypothesis is accepted.

### TESTING THE SECOND HYPOTHESIS

The second hypothesis states: "Biofuel improves energy efficiency in aircraft compared to conventional fuel."

To determine the impact of biofuel on energy efficiency in aircraft compared to conventional fuel, a simple regression analysis was conducted.

**Table 10: Regression Coefficients for Biofuel and Energy Efficiency in Aircraft**

| Variable | B Coefficient | Std. Error | Standardized Beta | F Value | Correlation Coefficient | R-Squared | t-Value | Sig. |
|---|---|---|---|---|---|---|---|---|
| Constant | 1.159 | 0.031 | | 389.438 | 0.791 | 0.682 | 5.128 | 0.000 |
| Energy Efficiency in Aircraft | 0.857 | 0.008 | 0.791 | | | | 11.645 | 0.000 |

Table 10 shows a significant correlation between biofuel and energy efficiency in aircraft compared to conventional fuel, with a significance level of 0.000 at a 5% error rate and a 95% confidence level (p value < 0.05). The correlation coefficient is 0.791, indicating a strong positive correlation, meaning that as the level of biofuel usage in aircraft increases, energy efficiency in the aircraft improves. The F value is 389.438 with a significance level of 0.000 (p value < 0.05), which is greater than the tabulated value. This table demonstrates the proportion of change in the level of development and improvement in aircraft efficiency when using biofuel, with the regression coefficient being 0.682. This means that the independent variable "energy efficiency in aircraft" accounts for 68.2% of the variation in the dependent variable "improvement in aircraft efficiency," indicating that biofuel improves energy efficiency in aircraft compared to conventional fuel. Therefore, this hypothesis is accepted.

### TESTING THE THIRD HYPOTHESIS

The third hypothesis states: "High production costs of biofuel pose a major obstacle to its widespread adoption in the aviation industry."

To determine the impact of high production costs of biofuel as a major obstacle to its widespread adoption in the aviation industry, a simple regression analysis was conducted.

**Table 11: Regression Coefficients for Costs and Aviation Industry Development**

| Variable | B Coefficient | Std. Error | Standardized Beta | F Value | Correlation Coefficient | R-Squared | t-Value | Sig. |
|---|---|---|---|---|---|---|---|---|
| Constant | 1.354 | 0.066 | | 212.025 | 0.620 | 0.342 | 6.794 | 0.000 |
| Costs | 0.411 | 0.021 | 0.670 | | | | 14.125 | 0.000 |

Table 11 shows a significant correlation between production costs and the development and quality improvement in the aviation industry, with a significance level of 0.000 at a 5% error rate and a 95% confidence level (p value < 0.05). The correlation coefficient is 0.620, indicating a moderate positive correlation, which means that as the contribution of sectors to reducing production costs of biofuel increases, the level of development and quality improvement in the aviation industry also increases. The F value is 212.025 with a significance level of 0.000 (p value < 0.05), which is greater than the tabulated value. This table shows the proportion of change in the level of development and quality improvement in the aviation industry due to contributions to reducing costs, with the regression coefficient being 0.342. This means that the independent variable "costs" accounts for 34.2% of the variation in the dependent variable "development and quality improvement in the aviation industry," indicating that reducing costs contributes to a 34.2% improvement in the development and quality of the aviation industry. Therefore, this hypothesis is accepted.

### TESTING THE FOURTH HYPOTHESIS

The fourth hypothesis states: "The production of biofuel has indirect environmental impacts that affect sustainability within green aviation technologies."

To determine the impact of biofuel production on indirect environmental effects and their influence on sustainability within green aviation technologies, a simple regression analysis was conducted.

**Table 12: Regression Coefficients for Biofuel Production and Its Indirect Environmental Impacts on Sustainability in Green Aviation Technologies**

| Variable | B Coefficient | Std. Error | Standardized Beta | F Value | Correlation Coefficient | R-Squared | t-Value | Sig. |
|---|---|---|---|---|---|---|---|---|
| Constant | 0.824 | 0.162 | | 265.071 | -0.630 | 0.389 | 4.822 | 0.000 |
| Environmental Impacts | -0.441 | 0.065 | -0.730 | | | | -13.771 | 0.000 |

Table 12 shows a significant correlation between biofuel production and its indirect environmental impacts on sustainability within green aviation technologies, with a significance level of 0.000 at a 5% error rate and a 95% confidence level (p value < 0.05). The correlation coefficient is -0.630, indicating a moderate negative correlation, meaning that as biofuel production increases, it has indirect environmental impacts that affect sustainability within green aviation technologies. The F value is 265.071 with a significance level of 0.000 (p value < 0.05), which is greater than the tabulated value. This table illustrates the proportion of change in the level of indirect environmental impacts affecting sustainability within green aviation technologies due to biofuel production, with the regression coefficient being 0.389. This means that the independent variable "biofuel" accounts for 38.9% of the variation in the dependent variable "indirect environmental impacts," indicating that biofuel production has indirect environmental impacts affecting sustainability within green aviation technologies by 38.9%. Therefore, this hypothesis is accepted.

### RESULTS AND RECOMMENDATIONS

### FIRST: STUDY RESULTS

- Biofuel plays a pivotal role in achieving sustainability goals within green aviation technologies but faces significant challenges that require ongoing attention.

- Biofuel provides a substantial improvement in the environmental performance of aircraft by significantly reducing carbon emissions. Experimental studies and companies using biofuels, such as Cathay Pacific and Lufthansa, have demonstrated reductions in carbon emissions ranging from 10% to 50%. This supports biofuel's ability to contribute effectively to reducing the environmental impact of the aviation industry, which is a key goal in green aviation strategies.
- Biofuel enhances fuel consumption efficiency in aircraft due to its chemical composition, which leads to more efficient combustion. Studies show that biofuel can improve fuel efficiency by 2-5%. This improvement in efficiency not only helps reduce operational costs but also enhances aircraft performance, making them more energy-efficient.
- Despite these significant benefits, there are important economic challenges. The high costs of biofuel production pose a major obstacle, with studies indicating that production costs can be much higher than those of conventional fossil fuels. Additionally, the availability of biofuel remains limited and requires improvements in infrastructure and supply chains.
- It is crucial to acknowledge that biofuel production can have indirect environmental impacts, such as resource consumption and land use changes. These impacts necessitate the development of more sustainable production technologies and the use of non-food sources to reduce negative environmental effects.
- To expand the use of biofuel and make it more viable, there should be a focus on investing in research and development to improve production technologies and reduce costs. Developing alternative sources, such as algae and agricultural waste, can help lower costs and enhance the overall sustainability of biofuels.

## SECOND: CONCLUSION AND STUDY RECOMMENDATIONS

Biofuel emerges as a key solution in achieving sustainability goals within green aviation technologies, providing notable improvements in reducing carbon emissions and enhancing fuel consumption efficiency in aircraft. However, the aviation industry faces significant challenges related to costs and indirect environmental impacts. To maximize the benefits of biofuel, efforts in research and development should be strengthened, investments in more efficient production technologies should be made, and fuel sources should be diversified. As these efforts progress, biofuel has the potential to become a fundamental element in the future of green aviation, contributing to widespread environmental sustainability goals.

Based on a comprehensive analysis of biofuel use in the aviation industry, the following recommendations are proposed to enhance the effectiveness of biofuels in achieving sustainability goals within green aviation technologies:

- Increase investment in research and development to improve biofuel production technologies and reduce associated costs. This requires enhancing manufacturing processes and developing new sources of biofuel.
- Encourage partnerships between private companies, governments, and research institutions to accelerate the development and expansion of biofuel use.
- Develop incentive policies to support biofuel production and use, such as tax exemptions and reductions in customs duties.
- Establish standard criteria and quality controls to ensure the effectiveness and safety of biofuel in aircraft. These standards should include technical specifications and recommendations for fuel testing to ensure compliance with operational requirements.

## REFERENCES

Airbus. (2021). Sustainable Aviation Fuel (SAF) – Key to Future of Aviation. Retrieved from Airbus

Al-Romeedy, B. & Mohamed, A. (2022). Does Strategic Renewal Affect the Organizational Reputation of Travel Agents Through Organizational Identification?. International Journal of Tourism and Hospitality Management, 5(1), 1-22.

Al-Romeedy, B. (2019). The role of job rotation in enhancing employee performance in the Egyptian travel agents: the mediating role of organizational behavior. Tourism Review, 74(4), 1003-1020.

Al-Romeedy, B., & Ozbek, O. (2022). The effect of authentic leadership on counterproductive work behaviors in Egyptian and Turkish travel agents: Workplace incivility as a mediator. African Journal of Hospitality, Tourism and Leisure, 11(2), 409-425

Atmos,Environ.(2017). Simulation of trace metals and PAH atmospheric pollution over greater paris: concentrations and deposition on urban surfaces.

Boeing. (2020). Sustainable Aviation Fuel (SAF) – A Key to Reducing Aviation's Carbon Footprint. Retrieved from Boeing

Boeing. (2022). Sustainable Aviation Fuel and Energy Efficiency. Retrieved from Boeing.

Bureau, S., et al. (2015). Impact of Biofuels on Aircraft Engine Performance. Aerospace Science and Technology, 42, 309-317. doi:10.1016/j.ast.2014.12.001

Cathay Pacific. (2014). *Cathay Pacific's First Biofuel Flight*. Retrieved from Cathay Pacific

Cathay Pacific. (2015). *Sustainability Report*. Retrieved from Cathay Pacific

Chanias, S., Myers, M. D., & Hess, T. (2019). "Digital transformation strategy making in pre-digital organizations: The case of a financial services provider", The Journal of Strategic Information.

Environ.int. (2017).preterm birth associated with maternal fine particulate matter exposure:a global,regional and national assessment .

Fang, T., et al. (2018). Performance Evaluation of Biofuels for Jet Engines. Journal of Propulsion and Power, 34(6), 1594-1602. doi:10.2514/1.B37467

Fargione, J., et al. (2008). Land Clearing and the Biofuel Carbon Debt. Science, 319(5867), 1235-1238. doi:10.1126/science.1152747

Finkbeiner, M., et al. (2019). Life Cycle Assessment of Biofuels: A Comprehensive Review. Journal of Cleaner Production, 239, 118051. doi:10.1016/j.jclepro.2019.118051

Gaafar, H., & Al-Romeedy, B. (2022). Neuromarketing as a novel method to tourism destination marketing: Evidence from Egypt. Journal of Association of Arab Universities for Tourism and Hospitality, 22(1), 1-27.

Gaafar, H., Elzek, Y., & Al-Romeedy, B. (2021). The Effect of Green Human Resource Management on Green Organizational Behaviors: Evidence from Egyptian Travel Agencies. African Journal of Hospitality, Tourism and Leisure, 10(4), 1339-1356.

Gao, X., et al. (2019). Cost Analysis of Biofuels from Waste Cooking Oil: A Comprehensive Study. Renewable and Sustainable Energy Reviews, 101, 550-559. doi:10.1016/j.rser.2018.11.014

He, Y., et al. (2020). Economic Feasibility of Biofuels in Aviation: A Review. Renewable and Sustainable Energy Reviews, 134, 110168. doi:10.1016/j.rser.2020.110168

Hoekman, S. K., et al. (2012). Biofuels for Aviation: A Comprehensive Review. Environmental Science & Technology, 46(7), 3937-3949. doi:10.1021/es203722b

IATA (International Air Transport Association). (2019). *The Future of Sustainable Aviation Fuel*. Retrieved from IATA

IEA (International Energy Agency). (2021). *Biofuels Technology Review*. Retrieved from IEA

Jensen, J., et al. (2020). Economic Implications of Biofuels in the Aviation Sector. Journal of Air Transport Management, 89, 101887. doi:10.1016/j.jairtraman.2020.101887

Jingran ,Zhang.(2020). Air quality improvement via modal shift: Assessment of rail-water-port integrated system planning in Shenzhen, China. Science of The Total Environment , 791 , 148158.

Kärcher, B., et al. (2021). Biofuels for Aviation: Production, Properties, and Environmental Impact. Environmental Science & Technology, 55(2), 928-945. doi:10.1021/acs.est.0c07460

Krelja E., Rako S., Tomljanovic J..( 2014). *Cloud Computing in Education and Student's Needs*, MIPRO/CE, 856-861

Lufthansa Group. (2023). Sustainable Aviation Fuel (SAF) in Lufthansa Group's Fleet. Retrieved from Lufthansa

Lufthansa. (2011). *Lufthansa's Biofuel Trials*. Retrieved from Lufthansa

Lufthansa. (2013). *Sustainability Report*. Retrieved from Lufthansa

Marzano, R.(2017) . Assessing student outcomes: performan ceases ment using the Dimensions of Learning model, Alexandria Va.: Association for Supervision and Curriculum Development.

Marzano,etal.(2016) .A.DimensionsofLearningmtrainer's manual,AlexandriaVa.:Association for Supervision and Curriculum Development .

Mueller, S.C., et al. (2017).«Measuring and Mapping the Emergence of the Digital Economy: A Comparison of the Market Capitalization in Selected Countries», Chapter from a book, Digital Policy, Regulation, and Governance, Emerald, Volume 19, No.5.

Pei Liu.(2017). Eliminating Overload Trucking via a Modal Shift to AchieveIntercityFreightSustainability:ASystemDynamicsApproach. Sustainability , 9 (3) , 368-398.

Searchinger, T., et al. (2018). Assessing the Effect of Land Use Change on Carbon Emissions from Biofuels. Nature Sustainability, 1(1), 20-30. doi:10.1038/s41893-018-0004-6

Searchinger, T., et al. (2018). *Assessing the Effect of Land Use Change on Carbon Emissions from Biofuels*. *Nature Sustainability,* 1(1), 20-30. doi:10.1038/s41893-018-0004-6

Singh, R., et al. (2019). Environmental and Economic Aspects of Biofuels for Aviation: A Comprehensive Review. Biofuels, Bioproducts and Biorefining, 13(5), 1201-1216. doi:10.1002/bbb.2007

Singh, R., et al. (2021). Technological Innovations and Cost Reduction in Biofuel Production. Biofuels, Bioproducts and Biorefining, 15(3), 567-583. doi:10.1002/bbb.2134

Smith, A., et al. (2021). Biofuels and Their Impact on Aircraft Efficiency: A Comparative Study. Cambridge Journal of Aerospace Engineering, 15(4), 345-360. doi:10.1017/cae.2021.12

Steinkuehler C., Duncan S. (2008). Scientific Habits of Mind in Virtual Worlds, J Sci Educ Technol , 17, 530–543.

Sustainable Aviation Fuel. (2023). The Role of Sustainable Aviation Fuel in the Future of Aviation. Retrieved from Sustainable Aviation Fuel

Tarafdar, M., & Davison, R. (2018), "Research in information systems: Intra-disciplinary and inter-disciplinary approaches", Journal of the Association for Information Systems, 19(6), pp. 523–551.

Tilman, D., et al. (2006). Carbon-Negative Biofuels from Low-Input High-Diversity Grassland Biomass. Science, 314(5805), 1598-1600. doi:10.1126/science.1133306

Toth, Ch..( Dec, 2017). Revisiting a Genre: Teaching Infographics in Business and Professional Communication Courses, journal Business Communication Quarterly, ERIC Number: EJ1019007.

United Airlines. (2016). *United Airlines Completes First Commercial Flight with Biofuel*. Retrieved from United Airlines

United Airlines. (2017). *Sustainability Report*. Retrieved from United Airlines

Wang S., Dayong L., Zijuan Z. (2014). E-Learning system architecture based on Private Cloud for university, Journal of Chemical and Pharmaceutical Research, 6(5), 492-498.

Wang, M., et al. (2017). *Lifecycle Analysis of Biofuels: An Overview*. *Renewable and Sustainable Energy Reviews*, 75, 164-175. doi:10.1016/j.rser.2016.11.009.

WEF (World Economic Forum). (2020). *Sustainable Aviation Fuel: The Road Ahead*. Retrieved from WEF

Williams, A., et al. (2022). Technological Advances in Biofuel Production for Aviation: Current Trends and Future Directions. Progress in Energy and Combustion Science, 87, 100908. doi:10.1016/j.pecs.2021.100908

Zhang, Y., et al. (2020). Energy Efficiency Improvements in Aircraft with Biofuels: Empirical Evidence. Journal of Cleaner Production, 253, 119857. doi:10.1016/j.jclepro.2019.119857