



Journal of Airline Operations and Aviation Management

The Netherlands Press

Article

Evaluating the Effectiveness of Sustainable Aviation in the Middle East: A Study of Two UAE-Based Carriers

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DOI: <https://doi.org/10.56801/jaoam.v2i1.6>

Abstract.

Middle East aviation industry comprises 4.5 percent of the global aviation market, thanks to its strategic location between all continents of the world and its position as a hub connecting the European and Asia-Pacific markets. The UAE is the biggest aviation market in the Middle East, with a 45 percent share of the region's aviation sector. This study evaluates the effectiveness of sustainable aviation by analysing the sustainability measures and strategies of two carriers: Emirates Airline and Etihad Airways. Thematic analysis of sustainability reports of the two carriers identified the environmental impacts of their operations and their measures and strategies to reduce greenhouse gas emissions in compliance with ICAO and IATA policies and targets within the pillars of sustainability: economic, social, and environmental. The study concludes that, despite the strategies and measures reported, the chances that both airlines would achieve 2050 net zero emissions target remains slim.

Keywords: aviation sustainability, greenhouse gases, environmental impact, environmental footprint, airline emissions.

Journal of Airline Operations and Aviation Management Volume 2 Issue 1

Received Date 06 March 2023

Accepted Date 13 April 2023

Published Date 15 August 2023

1. Introduction

The aviation industry is an important aspect of any country's economy. Every year, an increasing number of people worldwide travel to near and far locations by air, often for short durations. The rapid development in the travel industry over the past 40 years has transformed air travel from a luxury mode of transportation for a few wealthy individuals into a common and preferred means of travel for most middle-class travellers, due to the growing airport network facilitating global travel between places, cheaper airfares. Other factors are higher incomes and the ability to travel to distant places over a short period of time [1], involving less time away from work. About 42 percent of global tourist travel takes place by air [2]. According to the World Economic Forum (WEF), in 2007 alone, the aviation industry contributed US\$426 billion to global GDP directly, an extra US\$490 billion indirectly, and a further US\$620 billion through facilitating global tourism, making a total contribution equal to 3.2 percent of global GDP, and accounting for 33 million jobs worldwide [3]. The two major aircraft manufacturers, Airbus and Boeing, forecast an annual growth rate of 5.3 percent and 4.8 percent respectively until 2024, considering strong competitions, more airline entrants and lower airfares [4].

The growth in air transportation has resulted in increased emissions of greenhouse gases (GHGs). The noise from jet engines also has a negative impact on the overall tranquillity of the environment. The global aviation industry currently accounts for almost 5 percent of the world's greenhouse gas emissions [5], and this is expected to increase significantly in the near future. The emissions from aircraft include carbon dioxide (CO₂), nitrogen oxides, sulphate aerosols, particulate matter, and water vapour leading to the formation of contrails, which contribute to radiative forcing and global warming [5, 6]. A trajectory from the United Nations' International Civil Aviation Organisation (ICAO) predicts that aviation emissions could triple by 2050 compared to the current level [7]. In addition, a significant increase in flight passenger miles around the world is estimated to grow by 4-5 percent between 2019 and 2038 [8]. This implies that commercial aviation will have a much greater climate impact in the future than now, unless more sustainable and efficient greenhouse gas (GHG) emission solutions are developed [9].

Commercial aviation is among the fastest-growing sectors in the global economy in terms of both revenues and greenhouse gas emissions [10]. It is widely held that the aviation industry requires a global framework to begin the process of reducing its greenhouse gas emissions on a scale and timescale commensurate to the challenge. In 1944, a specialized agency of the United Nations, the International Civil Aviation Organisation (ICAO) was created to promote the safe and orderly development of international civil aviation throughout the world. The ICAO serves as the forum for cooperation in all fields of civil aviation among the 191 United Nations Member States. It sets the standards and regulations necessary for aviation safety, security, efficiency and regularity, as well as for aviation environmental protection [11]. In recognition of the growing environmental impacts from the international aviation sector, the ICAO Council created the Committee on Aviation Environment Protection (CAEP) and gave it lead responsibility for responding to climate-change-related issues. Apart from the ICAO, other private sector organisations, such as the International Air Transport Association (IATA) and the Air Transport Action Group (ATAG) have emerged to tackle the environmental impacts of the aviation industry.

This study focuses on the aviation industry in the Middle East region, with emphasis on the United Arab Emirates (UAE). Though aviation is an industry which operates globally, with international legislation governing its operations, national rules and regulations differ from country to country, and the implementation of measures is, to some extent, geographically bound. The Middle East aviation industry has experienced a rapid rise to global industry prominence over the past decade or so, and is generally viewed from outside the Middle East as a homogenous cluster of airlines seeking to develop substantial transfer hubs connecting the world via their advantageous geographical locations [12, 13]. The Middle East benefits from its strategic location between all the continents of the world and its position as a hub connecting the European and Asia-Pacific markets [14, 15]. The region has a 4.2 percent share of global air passenger traffic [4]. In 2018, the aviation sector contributed US\$213 billion (7.6%) to the GDP of the Middle East and supported 3.4 million (4.5%) jobs [4]. Moreover, air passenger traffic in the region is expected to double by 2030 [16], and the economic benefits of investment in air traffic management could be above US\$16 billion by that time [17]. With three world-class airports, including the busiest in the world, millions of passengers travelling through these airports and many highly competitive local and international airlines operations, the UAE is one of the biggest and most dynamic aviation markets in the world [18]. Between 1995 and 2018, the contribution of the travel and tourism industry to the GDP of the UAE almost tripled from 4 percent to above 11 percent [19]. Whilst petroleum sources still dominate UAE's economy, the aviation industry is prosperously growing and helping the country economically diversify away from crude oil. The two UAE-based full-service carriers, Emirates Airline and Etihad Airways, contribute to the rising number of tourists as they link the country with a large network of global cities.

The crucial role of aviation in the UAE's economy demands an evaluation of the sustainability practices of the country's aviation sector. Furthermore, the UAE is committed to the ICAO's net zero GHG emissions by 2050. Hence, this study critically evaluates the effectiveness of the current sustainability measures and strategies of Emirates Airline and Etihad Airways within the three pillars of sustainability, i.e., economic, social, and environmental, in line with ICAO and IATA policies and targets for reducing greenhouse gas emissions due to aviation.

2. Literature Review

2.1. Environmental Impacts of Aviation

Despite the vital role of aviation in supporting economies and societies through tourism, business, imports and exports, which are increasingly becoming interconnected by globalisation, there are unprecedented levels of concern about the quality of life of increasing numbers of people and effects on the local and global environment. The emissions of greenhouse gases from aircraft and airports contribute to climate change and localised air pollution, and aircraft noise adversely affects populations who live, work and study in the vicinity of airports. As the demand for air travel grows, these already acute environmental impacts will likely increase in scale and scope; hence, balancing the trade-off between the growing demand for air transport and its environmental impacts presents policymakers and the aviation industry with a major challenge [20]. A scientific understanding of the environmental impacts of aviation is an essential basis for informed policy discussions, and for the development of effective mitigation measures that can achieve the desired outcome in a cost-effective manner [1].

2.1.1 Climate Change

Like all other human activities involving combustion, aviation releases carbon dioxide (CO₂) and other greenhouse gases into the atmosphere, which accelerates global warming and ocean acidification. Apart from CO₂ emissions from aircraft in flight, the aviation industry emits greenhouse gases from airport ground vehicles used by the passengers and staff to access the airports and energy used in airport terminals, the manufacture of aircraft and the construction of airport infrastructure. The overall contribution of aviation to global warming is estimated to be 2-5 times higher than the radiative forcing of its CO₂ emissions alone [21]. In addition to CO₂, which is the principal greenhouse gas emitted from aircraft in flight, other greenhouse gases emitted include nitric oxide and nitrogen dioxide (together designated NO_x), water vapour and particulates (soot and sulphate particles), sulphur oxide, carbon monoxide (which results from incomplete oxidation of carbon in air), unburnt hydrocarbons (UHCs), tetraethyl lead (piston-engine aircraft only), and radicals such as hydroxyl, depending on the type of aircraft in use [1].

2.1.2 Aircraft Noise

Aircraft noise is a harmful effect produced by various components of an aircraft during the different segment of its flight schedule. The adverse impact is felt most by the environment surrounding an airport when the aircraft is either on the ground for taxi and take-off or in its climbing schedule.

A summary of the environmental impacts of aviation, with examples, is presented below

Table 1: ICAO Inventory of Aviation Environmental Impacts

Environmental impacts	Examples
Aircraft noise	Aircraft operations Engine testing Airport sources Sonic boom
Local air pollution	Aircraft engine emissions Emissions from airport access traffic Emissions from airport motor vehicles Emissions from other airport sources
Global phenomena	Long-range air pollution (e.g, acid rain) Greenhouse effect Ozone depletion Climate change
Airport/infrastructure construction	Loss of land Soil erosion Impacts on water tables, river courses and field drainage Impacts on flora and fauna
Water and soil pollution	Pollution due to contaminated run-off from airports Pollution due to leakage from storage tanks
Waste generation	Airport wastes Wastes generated in-flight Toxic materials from aircraft servicing and maintenance
Aircraft accidents/incidents	Accidents/incidents involving dangerous cargo Other environmental problems due to aircraft accident Emergency procedures involving fuel dumping

Source: Adapted from Daley (2010)

2.2. Sustainable Aviation

Sustainable aviation is a multidisciplinary approach that seeks to improve the environmental and social impacts of air transportation. It is a long-term strategy which aims to reduce aviation's contribution to climate change through new practices and radical innovations to ensure a cleaner, quieter, and eco-friendly future for the aviation industry [22, 23]. This can be achieved through highly efficient aircraft designs, novel propulsion systems, green aircraft technologies (e.g., renewable and alternative energy sources like electrified and hydrogen-powered aircrafts, sustainable aviation fuels (SAFs)), improved air traffic management, and energy optimised flight operations to reduce aircraft energy consumption, noise, and emissions.

2.3. The Middle East Aviation Industry

According to the World Tourism Organisation (WTO), the Middle East consists of 15 countries: Bahrain, Egypt, Iran, Iraq, Israel, Jordan, Kuwait, Lebanon, Oman, Qatar, Saudi Arabia, Syrian Arab Republic, Turkey, United Arab Emirates, and Republic of Yemen [2] (see Figure 1). The region is home to many prominent full-service carriers operating long-haul flights, such as Emirates Airline, Etihad Airways, Qatar Airways and Turkish Airlines offering high Revenue-Ton-Kilometres (RTK) and Revenue-Passenger-Kilometres (RPK) compared to US and European carriers [24]. The Middle East aviation industry has experienced significant growth in the past 27 years due to international tourism, though it slowed in 2020 and 2021, owing to the COVID-19 pandemic. Tourist arrivals in the Middle East nearly tripled in 9 years—from 14 million arrivals in 1995 to more than 35 million arrivals in 2004 [2]. This makes tourism a fundamental driver of economic growth in the region. The Middle East air transport market constitutes 4.5 percent of the global aviation market [14]. Air travel in the Middle East is predicted to grow at roughly 4.1 percent per annum over the next two decades, drive growth in economic output and jobs that are supported by the aviation industry over the next 20 years, and it is also projected that the impact of the aviation industry and the tourism it facilitates will grow to support 6.7 million jobs and contribute \$517 billion to the Middle East GDP by 2038 [4].

In recent decades, the Middle Eastern country of the United Arab Emirates has witnessed speedy growth in tourism, travel, and its all-around economic position as a result of massive government investment in the aviation industry and the UAE's strategic location between Europe and Asia [15, 18, 25]. The UAE has the biggest aviation market in the region, accounting for about 45 percent of the Middle East aviation sector [26]. According to ATAG [14], the aviation industry contributed US\$47.1 billion (11.3%) to the GDP of the UAE and provided more than 777,000 jobs in 2017. The UAE is ranked 3rd worldwide in terms of RTK and RPK, only behind the US and China, and its largest city, Dubai has the largest international airport terminal in the world, and the 3rd largest by total passengers [26]. Dubai International Airport is also the busiest in the world by international passengers [25, 27]. The aviation sector has played a key part in the transformation of the UAE economy from oil dependency since the 1980s and this has helped in developing other sectors, including tourism, hospitality, logistics, and trade and finance [25].

Sustainable aviation has been a top priority for the UAE's major carriers, Emirates Airline and Etihad Airways, with both publishing reports of their sustainability measures and strategies, which will be evaluated in detail in the following sections.

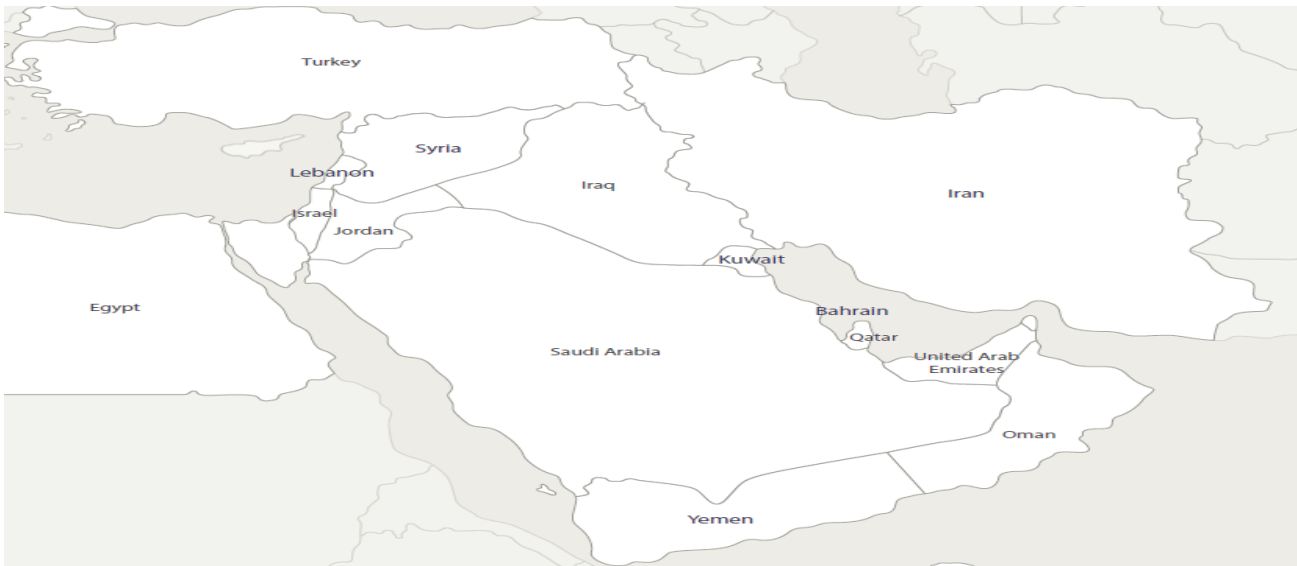


Figure 1. Map showing 15 Middle East countries

Source: Adapted from online.seterra.com/en (2022)

2.4. International Organisations and Regulations to reduce aviation environmental impacts

2.4.1 International Civil Aviation Organisation (ICAO)

The ICAO formulates policies, develops and updates standards and recommended practices on aircraft emissions, as well as conducting outreach activities to minimise the adverse effects of international civil aviation on world climate. In 2019, the ICAO Member States agreed on three global goals for international aviation [28]:

- 2 percent annual fuel efficiency improvement from 2019 to 2050;
- stabilising net aviation CO₂ emissions at 2020 levels through carbon neutral growth; and
- halving net CO₂ emissions from international civil aviation by 2050 compared to 2005 levels.

Note: As at 2005, net CO₂ emissions were below 500 megatons (500,000,000 tonnes) [29].

The ICAO is pursuing several measures, including aircraft technology, operational improvements, sustainable aviation fuels, and market-based measures (CORSIA) to achieve these goals.

2.4.2 International Air Transport Association (IATA)

IATA is the trade association for the world's airlines, representing around 265 airlines or 83 percent of total air traffic [30]. IATA supports many areas of aviation activities and helps to formulate industry rules, policies, targets, and responses on critical aviation issues such as reducing carbon emissions [10, 30].

2.4.3 Air Transport Action Group (ATAG)

ATAG is a platform for the global commercial aviation sector to work together on long-term sustainability issues. With about 40 members worldwide and membership spread across the entire aviation value chain, it allows a robust basis for speaking with international decision makers and represents a broad industry view. Members include airports, airlines, airframe and engine manufacturers, air navigation service providers, leasing companies, airline pilot and air traffic controller unions, aviation associations, chambers of commerce, tourism and trade partners, ground transportation, communications providers, IATA, etc. [31].

3. Methodology

3.1 Research Goal

The goal is to evaluate the sustainability measures and strategies of both Emirates airline and Etihad airways in the past seven years (i.e., from 2015-2021) by analysing their published sustainability reports and checking their compliance with ICAO and IATA policies and targets for reducing greenhouse gas emissions due to aviation.

This thematic analysis was considered within the economic, social, and environmental pillars of sustainability [32]:

- Economic sustainability refers to honest and transparent accounting practices, financial statements and reporting in conformity with regulatory standards.
- Social sustainability encompasses practices that consider the benefit and welfare of the employees, passengers, stakeholders and the wider community.
- Environmental sustainability focuses on reducing greenhouse gas emissions and aircraft noise.

3.2 Emirates Airline Sustainability Report (2015-2021)

Emirates Airline started with US\$10 million seed funding from DNATA (Dubai National Air Transport Association), a transport company established by the government of Dubai at the new Dubai International Airport. It began with just two aircraft leased from Pakistan and some technical crew, in addition to administrative support and operated by flying out mostly as an aircraft carrier that connected passengers from and to Dubai [33]. On 25 October 1985, Emirates operated its first flight from Dubai to Karachi and Mumbai using a Boeing 737 and an Airbus 300 B4, wet-leased from Pakistan International Airlines. Today, Emirates Airline, which operates from the Dubai International Airport is one of the largest international airlines, flying in all continents around the globe, with more than 135 destinations [34].

The table below is based on Emirates Airline’s sustainability report from 2015-2021, covering emissions from flight operations, jet fuel and engine, ground operations, and aircraft noise.

Table 2: Emissions from flight operations, jet fuel and engine, and ground operations

Metric	Emission Type	Unit	2015	2016	2017	2018	2019	2020	2021
Flight operations	CO ₂	tonnes	28,273,348	31,884,260	34,645,211	35,438,672	36,593,909	34,380,099	11,042,736
Jet fuel and engine (below 3,000 feet landing/take-off cycle)	NO _x	tonnes	11,255	12,633	13,791	13,971	14,127	13,126	5,379
	CO	tonnes	7,082	8,120	9,260	9,581	9,622	8,913	3,027
	UHCs	tonnes	754	876	1,018	1,050	1,040	955	309
Ground operations	CO ₂	tonnes	113,693	135,244	138,708	148,599	144,593	139,330	63,934
Total CO₂ emissions from flight and ground operations	CO ₂	tonnes	28,387,041	32,019,504	34,783,919	35,587,271	36,738,502	34,519,429	11,106,670

Source: The Emirates Group Environmental Report 2015, 2016, 2017, 2018

The Emirates Group Annual Report 2019, 2020, 2021

Table 3: Aircraft Noise

Metric	Unit	2015	2016	2017	2018	2019	2020	2021
Aircraft compliance with ICAO Annex 16 Vol I Chapter 4 Standards	%	100	100	100	100	100	100	100
Margin to ICAO Chapter 4 in Effective Perceived Noise in Decibels	EPNdB	-9.95	-10.31	-10.85	-11.08	-11.41	-11.71	-11.80
Percentage margin below ICAO Chapter 4	%	-6.44	-6.55	-6.71	-6.78	-6.88	-6.98	-7.00

Source: The Emirates Group Environmental Report 2015, 2016, 2017, 2018

The Emirates Group Annual Report 2019, 2020, 2021

3.3 Etihad Airways Sustainability Report (2018-2021)

Etihad Airways, which is the national carrier of the United Arab Emirates, is fully owned by the government of Abu Dhabi. It was formally established by a monarch's decree in July 2003 to recognise the aviation industry's crucial role in a diverse global economy, and in November 2003, the first Etihad Airways flight departed Abu Dhabi International Airport to arrive at Beirut [27]. Etihad was founded as a flagship carrier for the Abu Dhabi government, out of the desire to catch up with Dubai (home of Emirates Airline) in becoming a global city, with a vision to reflect the considerate, cultured, generous and warm Arabian hospitality and enhance the prestigious position of Abu Dhabi as the capital city [18, 27]. Etihad's rapid success is linked to compelling advertisements, extensive publicity and adoption of all feasible marketing strategies, including market expansion, market sustainability and international collaborations, making it the world's fastest-growing airline, with current flight operations in all the six continents [35].

The table below is based on Etihad Airways' sustainability report from 2018-2021, covering carbon footprints from aircraft fuel burn, ground operations, and waste to landfill.

Table 4: Carbon footprints from aircraft fuel burn, ground operations, and waste to landfill

	Unit	Conversion factor	Tonnes CO ₂ per year			
			2018	2019	2020	2021
Aircraft fuel burn	Kg	3.150tCO ₂ /tfuel	9,714,898	9,014,084	4,207,328	4,215,343
Ground operations	Litre	2.70kgCO ₂ /litre	6,264	8,426	8,620	2,570
Waste to Landfill - Etihad Complex	Kg	487kgCO ₂ e/tonne	81,407	62,952	43,923	71,367
Total tonnes of CO₂			9,802,569	9,085,462	4,259,871	4,289,280

Source: Etihad Airways Sustainability Report 2020-2021

3.4. ICAO and IATA compliance

Tables 2, 3 and 4 show the environmental impact of both Emirates Airline and Etihad Airways. Pursuant to ICAO engine emission standards as contained in Annex 16, Volume II [36], which encompasses emission standards for NO_x, CO, and UHCs based on an aircraft's landing and take-off (LTO) cycle, Emirates Airline shows signs of improvement in the reduction of these emissions. From 2019 to 2021, there was a consistent decrease in the emission of NO_x, CO,

and UHCs towards reaching the standards of 15g/1kg fuel for NO_x, <0.6g/1 kg fuel for CO, and <0.01g/1kg fuel for UHCs.

In reference to aircraft noise, ICAO Annex 16, Volume I (Chapter 4) [37], which contains provisions related to aircraft noise and specified standards, Emirates Airline was operating within acceptable noise limits over the years covered in the sustainability report.

For CO₂ which remains the primary greenhouse gas, Emirates Airline had 156 percent CO₂ reduction between 2015 and 2021 from 28,387,041 tonnes to 11,106,670 tonnes. Etihad Airways reduced CO₂ by nearly 129 percent between 2018 and 2021 from 9,802,569 tonnes in 2018 to 4,289,280 tonnes in 2021. Though these figures represent significant improvement from both airlines in reducing their carbon footprint, it is still far from the 2050 net zero carbon emission targets of ICAO and IATA.

4. Findings

The sustainability reports of Emirates Airline were found to contain clearly focused sustainability measures and strategies and an ambitious drive to reduce the environmental impacts from their operations using globally accepted honest and transparent accounting and reporting practices [32]. Kim and Son [38] observed that many airlines do not reveal their environmental data, such as reduction in energy consumption, reduction in materials and elimination of wastes, aircraft noise, elimination of single-use plastics, reduction in electricity and water consumption, aircraft weight reduction initiatives, and promotion of alternative fuels; however, Emirates Airline's annual sustainability reports from 2015-2021 disclosed sufficient data on these environmental variables. Etihad Airways, which began operations in 2003, released its first ever sustainability report in April 2022, covering only its operation from 2018-2021 and aircraft noise was missing from the report. Unlike Emirates Airline, this does not signify a positive corporate social responsibility policy.

Secondly, there are concerns about local air quality due to aviation; the major types of engine emissions that can have impact on local air quality, which are internationally regulated by ICAO Standards as contained in ICAO Annex 16 Volume II, include emissions from NO_x, CO, and UHCs. However, Etihad Airways did not highlight the significance of these emissions in their sustainability report. Studies have shown that NO_x, CO, and UHCs are most relevant below 3,000 feet in terms of air quality impacts [39, 40]. Emirates Airline, on the other hand, considers this by reporting on the emissions of NO_x, CO, and UHCs below 3,000 feet, using ICAO's landing/take-off (LTO) cycle. Emissions were calculated for the landing and take-off cycle (LTO cycle) as per the applicable ICAO certification Standards and based on the manufacturers' certified engine emissions values. Moreover, Emirates Airline reports that it applies other operational initiatives, such as switching off one engine while taxiing on the ground where operationally possible and using ground power when available instead of the on-board auxiliary power unit (APU), which all help to reduce emissions on the ground.

Thirdly, the voluntary Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA) developed in October 2016 requires aircraft operators to offset CO₂ emissions from international flights through the use of market-

based environmental policy instruments to curb the impact of aviation on climate change. Aircraft operators will have to purchase carbon credits from the carbon market to offset their emissions above 2020 levels, starting from 2021 [41]. As at 2021, Emirates Airline had completed its first audited annual emissions report for CORSIA, covering all of its international emissions for the year 2019 and was finalising the audited report for 2020. However, Etihad Airways will be obliged to purchase carbon credits to offset post-2020 absolute emissions, if it fails to meet target for the voluntary pilot phase which commenced in 2021.

Finally, in the area of Sustainable Aviation Fuel (SAF), there is great potential for securing the sustainable growth of air travel as this could reduce CO₂ emissions by about 80 percent compared to fossil fuels, without the need to change the fuel supply systems or engines of aircraft [42]. Resolution A40-18 of ICAO [29] acknowledged the need for SAF to be developed and deployed in an economically feasible, socially and environmentally acceptable manner. Etihad Airways has demonstrated a strong commitment by introducing sustainable aviation fuels from various sources into its energy mix. Emirates Airline and GE Aviation recently signed an MoU that will see a Boeing 777-300ER, powered by GE90 engines, conduct a test flight using 100 percent sustainable aviation fuel (SAF) by the end of 2022. In fact, the 2021/2022 sustainability report shows that aircraft fuel consumption, fuel efficiency and CO₂ efficiency improved due to the increased use of sustainable aviation fuels from 77 tonnes in 2021 to 153 tonnes in 2022.

5. Conclusion

The UAE is fully engaged in the reduction of greenhouse gases and remains very active on all issues dealing with climate change, including being among the first countries to agree to the ICAO's CORSIA. The airlines are also committed to the implementation of operational changes, and improvements in air traffic management and airport systems. Both Emirates Airline and Etihad Airways have continually demonstrated efforts towards reduction in fuel consumption and carbon emissions, despite the strong competition in the airline industry and the impacts of the COVID-19 pandemic on civil aviation.

The ICAO and IATA measures and strategies to regulate the environmental impacts of aviation within the pillars of economic, social, and environmental sustainability through CORSIA, alongside technology, sustainable aviation fuel, infrastructure enhancements, and operational efficiency, are a good step in the right direction for international civil aviation towards the 2050 goal of cutting CO₂ emissions by 50 percent compared to 2005 levels.

With 28 years left and Emirates Airline and Etihad Airways having already begun introducing new technologies and replacing older aircraft with newer and more efficient ones, implementing market-based measures to offset emissions that cannot be reduced through technological, operational or infrastructural measures, and by using sustainable aviation fuel, there is a slim possibility that both could achieve the 2050 target.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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