ISSN: 2637-6067 DOI: 10.6918/IJOSSER.202312_6(12).0008

Comparative Analysis of Low-Carbon Operations at Hong Kong International Airport Before and After the COVID-19 Pandemic: Costs and Models

Siyang Liu[1, a]

[1]Department of European & International Studies, King's College London, London, WC2R 2LS, United Kingdom

[a]siyang.liu@kcl.ac.uk

Abstract

The aviation industry, a notable contributor to greenhouse gas emissions, has been actively seeking pathways to align with the Paris Agreement's objectives. Major global airports have embarked on transformative journeys towards low-carbon operations. The unexpected onset of the COVID-19 pandemic in late 2019, however, posed unparalleled challenges to these endeavors. Therefore, this paper aims to provide a comparative analysis of the low-carbon operations at Hong Kong International Airport (HKIA) before and after the COVID-19 pandemic. By using data from official reports and newsletters, this study examines the environmental and economic impacts of the pandemic on HKIA's sustainability initiatives. The findings reveal that while the pandemic led to an involuntary reduction in operations and subsequent decrease in carbon emissions, HKIA's commitment to sustainability remained steadfast. Despite the challenges, HKIA demonstrated resilience and adaptability, emphasizing the importance of strategic planning in the face of global adversities.

Keywords

COVID-19 pandemic; Sustainability; Low-carbon; Impact on aviation; Hong Kong International Airport.

1. Introduction

The escalating global climate crisis has underscored the urgency of reducing greenhouse gas emissions and championing low-carbon operations. The "greenhouse effect," primarily driven by gases like carbon dioxide and methane, is accelerating Earth's temperature rise. The Paris Agreement of 2015 stands as a testament to global commitment, aiming to limit the temperature increase to 1.5 degrees Celsius above pre-industrial levels. To honor this pact, nations and industries are striving to curtail emissions and bolster climate change resilience.

Parallel to these environmental concerns, the global tourism industry, fueled by economic growth and an expanding middle class, has witnessed exponential growth. The aviation sector, integral to this industry, has emerged as a significant contributor to greenhouse gas emissions. Airports, being pivotal nodes in international transportation, have operations that are energy-intensive. Ground transportation, daily operations, and terminal activities at airports contribute substantially to their carbon footprint. Recognizing the magnitude of their impact, major airports globally have initiated measures to transition to low-carbon operations. Initiatives range from carbon offset programs, as seen at London Heathrow Airport, to the adoption of electric buses at Los Angeles International Airport [1].

However, the advent of the COVID-19 pandemic in late 2019 introduced unprecedented challenges to airport operations [2]. While the pandemic-induced travel restrictions have

ISSN: 2637-6067 DOI: 10.6918/IJOSSER.202312_6(12).0008

strained airport finances, they have also inadvertently reduced carbon emissions, presenting a unique scenario for low-carbon operations research.

This paper focuses on the Hong Kong International Airport (HKIA), a pivotal player in the global aviation landscape. Established in 1998, HKIA's strategic location positions it as a vital link between mainland China and the world [3]. As a bustling hub, HKIA facilitates the movement of millions of passengers and significant cargo volumes annually. Before the pandemic, Hong Kong's allure drew in 58.47 million and 65.15 million tourists in 2017 and 2018, respectively [4]. Given HKIA's global significance, understanding its low-carbon strategies can offer insights for the broader aviation sector, propelling it towards sustainability.

In essence, this study endeavors to analyze HKIA's low-carbon operational costs and models, particularly in the post-pandemic era. The findings aim to provide actionable insights for the sustainable evolution of the aviation industry.

2. Literature Review

Scholars have been employing diverse methods to evaluate airport sustainability. While substantial research and strategic advancements in low-carbon operations are evident in European and North American airports, such in-depth studies remain sparse in Asia, especially for major hubs like Hong Kong. Prior to the pandemic, the focus of most research was on specific low-carbon policies or individual measures. For example, Allen (2019) outlined a series of zero-emission and emission-reduction strategies for the U.S. aviation sector, emphasizing various facets of airport operations [5]. Similarly, Qiu (2021) delved into the evolving trends of low-carbon aviation transportation and assessed the impact of associated policies [6]. While these studies present innovative approaches to low-carbon operations, many lack a comprehensive, macro-level analysis of the costs and models, particularly in the context of the post-pandemic era.

In recent times, a surge of comprehensive studies has emerged to understand the relationship between the COVID-19 pandemic and air transport. Sun (2022) meticulously reviewed nearly 200 papers from 2021/2022 on the interplay between COVID-19 and the aviation sector, categorizing them down to specific niches [7]. Notably, the sustainability category from Sun's review lays a robust groundwork for this study. Sun discerned that a predominant theme within the sustainability literature was the analysis of emission changes during and post-pandemic [7]. Hemmings (2021) further enriched the discourse by employing a combination of detailed questionnaires and semi-structured interviews [8]. His objective was to discern how the pandemic influenced airport operators' decision-making processes regarding climate change mitigation [8]. Intriguingly, Hemmings' findings underscored that despite the colossal economic and operational challenges posed by the pandemic, airport operators remained unwavering in their commitment to low-carbon and sustainable development [8]. Tsui (2021) embarked on an empirical exploration into the determinants driving Hong Kong's inbound tourism from January 2019 to December 2020 [4]. His analysis revealed that the pandemic exerted disproportionate negative impacts on Hong Kong's tourism and aviation sectors [4]. This insight from Tsui not only reinforced the pertinence of focusing on HKIA for this study but also highlighted the pandemic's overarching influence on the aviation sector.

Collectively, post-2021 literature concerning aviation and low-carbon objectives has increasingly pivoted towards understanding the pandemic's ramifications. This trend provides the crucial context and direction for this study.

ISSN: 2637-6067 DOI: 10.6918/IJOSSER.202312_6(12).0008

3. Method

In the quest to understand the implications of the COVID-19 pandemic on the low-carbon operations of HKIA, this study adopts a primarily qualitative research approach. The primary data source is the official reports from HKIA, with a particular emphasis on the Airport Sustainability Report. Recognized as a critical tool for airports worldwide, the Sustainability Report offers a comprehensive insight into an airport's environmental performance. This study is structured around two primary objectives: 1. To juxtapose the operational, economic and environmental data of HKIA before and after the pandemic's onset. 2. To discern the shifts in the airport's low-carbon operational models pre and post-pandemic.

To achieve a holistic understanding, I will delve into the low-carbon operating capital costs, strategies, and the evolution of the operational model spanning from 2018 to 2023, with a keen focus on the years impacted by the pandemic. Subsequently, I will seek correlations between the data, operational models, and the timeline of COVID-19 outbreaks. Given the unprecedented nature of the COVID-19 crisis, it is anticipated that the pandemic will have exerted a substantial influence on HKIA's operational metrics.

3.1. Operational, economic, and environmental data

Based on the 2022/23 Hong Kong International Airport Sustainability Report, it's evident that the pandemic has influenced all operational, economic, and environmental indicators between 2020 and 2023 [9]. Most notably, there was a significant downturn in 2020/21 across these metrics. In the provided datasets, figures marked with an asterisk (*) for the pandemic-affected years potentially signify deviations from the typical year-on-year performance trends [9]. Given the focus of this paper on the low-carbon operations within the airport terminal, only relevant data from the operational and economic sectors will be incorporated into the subsequent analysis.

3.1.1. Operational data

Operational Data

	Unit	2018/19	2019/20	2020/21	2021/22	2022/23
Air traffic data						
Passenger traffic[1]	Millions of passengers	75.1	60.9	0.84*	1.43*	**12.4***
Cargo throughput[2]	Millions of tonnes	5.1	4.7	4.6	4.9	**4.1**
Aircraft movement[3]	Thousands	429	377	128*	145*	**161***
Connectivity						
Passengers using land-based cross-boundary transport[4]	Thousands of passengers	1,971	1,519	0*	0*	**68***
Number of cross-boundary land destinations[4]	Number	110	110	0*	0*	**22***
Passengers using SkyPier	Thousands of passengers	2,494	1,890	25*	104*	**224***
Number of cross-boundary seaports served	Number	9	9	4*	1*	**4***

Figure 1. HKIA Operational Data from 2018 to 2023

The impact of the pandemic on air traffic and connectivity is evident in the data, with a marked decline in passenger traffic and aircraft movement in 2020/21. Although there's been a steady recovery in subsequent years, the figures remain significantly below pre-pandemic benchmarks. Land-based cross-boundary transport came to a complete standstill in 2020/21 and 2021/22, only to see a modest resumption in 2022/23. In essence, while there are indications of a rebound in 2022/23, the overarching narrative underscores the profound disruption caused by the pandemic on transport operations, with current metrics still lagging behind their pre-pandemic counterparts.

ISSN: 2637-6067 DOI: 10.6918/IJOSSER.202312_6(12).0008

3.1.2. Economic data

Economic Data

	Unit	2018/19	2019/20	2020/21	2021/22	2022/23
Economic performance[1]						
Economic value generated						
Revenue	HK$ million	19,470	17,106	5,936*	5,798*	**8,217***
Economic value distribution						
Operating costs[2]	HK$ million	7,027	7,886	8,054	6,176	**7,404**
Employee wages and benefits	HK$ million	3,182	3,638	3,760	3,754	**3,902**
Financial donations	HK$ million	4	3	2	1	**1**
Payments to providers of funds[3]	HK$ million	79	221	767*	1,203*	**2,460**
Payments to government[4]	HK$ million	1,498	1,195	106*	34*	**8**
Economic value retained[5]						
Economic value retained	HK$ million	10,866	7,804	(2,991)*	(1,615)*	**(1,655)***

Figure 2. HKIA Economic Data from 2018 to 2023

The data reveals a pronounced decline in revenue from 2020/21, a direct consequence of the pandemic. Although there's a modest uptick in 2022/23, it remains considerably below pre-pandemic figures. Interestingly, operating costs surged in 2020/21 despite the revenue downturn, suggesting potential inefficiencies or unavoidable fixed expenses due to policies of the pandemic. These costs saw a brief dip in 2021/22 but climbed again the following year. Payments to providers of funds witnessed a stark rise from 2020/21, possibly hinting at augmented borrowing or heightened financial commitments during the pandemic. Concurrently, payments to the government plummeted, likely a result of diminished profitability coupled with governmental relief initiatives. Notably, the economic value retained, which was positive before the pandemic, transitioned into the negative from 2020/21, signifying operational losses. In essence, while there's a glimmer of revenue recovery in 2022/23, the overarching narrative is one of economic adversity during the pandemic, underscored by the negative retained value and escalating payments to fund providers.

3.1.3. Environmental data

Environmental Data[1]

	Unit	2018	2019	2020	2021[2]	2022[3]
Greenhouse gas (GHG) emissions[4,5]						
S1 Scope 1 – Direct emissions						
Stationary emissions	Tonnes ('000) of CO_2e	0.15	0.13	0.11	0.11	**0.10**
Mobile emissions	Tonnes ('000) of CO_2e	3.06	2.73	1.34*	1.23*	**1.37***
Fugitive emissions	Tonnes ('000) of CO_2e	6.9	8.19	0.68*	2.84*	**5.23**
S2 Scope 2 – Indirect emissions						
Electricity[6]	Tonnes ('000) of CO_2e	151.14	153.39	80.61*	89.84*	**94.90***
S3 Scope 3 – Other indirect emissions from key business partners' operations						
Pledged business partners' Scope 1 & 2 emissions (29 in total)[7]	Tonnes ('000) of CO_2e	203.64	200.00	130.66*	126.04*^	**140.32***

Figure 3. HKIA Environmental Data from 2018 to 2022 (1)

ISSN: 2637-6067 DOI: 10.6918/IJOSSER.202312_6(12).0008

	Unit	2018	2019	2020	2021[2]	2022[3]
S3 Scope 3 – Other indirect ground emissions from AAHK and third parties						
Staff business travel	Tonnes ('000) of CO_2e	0.31	0.39	0.01*	0.001*	**0.07***
Passenger and staff surface access	Tonnes ('000) of CO_2e	121.22	104.37	15.31*	5.82*	**10.41***
Electricity consumption for processing fresh water and sewage	Tonnes ('000) of CO_2e	0.19	0.18	0.17	0.12	**0.12**
Waste disposal	Tonnes ('000) of CO_2e	20.56	21.97	9.91*	6.76*^	**9.39***
Tenants' energy	Tonnes ('000) of CO_2e	52.48	46.62	10.2*	14.18*^	**13.76***
Emissions avoided by tree planting and paper recycling[8]	Tonnes ('000) of CO_2e	(1.13)	(0.78)	(0.74)	(0.72)	**0.001**
Other business partners' Scope 1 & 2 emissions[9]	Tonnes ('000) of CO_2e	31.51	29.03	20.46*	19.60*^	**21.82***
Non-road construction machinery and equipment	Tonnes ('000) of CO_2e	N/A	N/A	N/A	123.84	**128.94**
Maritime access	Tonnes ('000) of CO_2e	N/A	N/A	N/A	0.04	**0.05**

^ This number has been restated following the verification for ACA accreditation in late 2022.

Figure 4. HKIA Environmental Data from 2018 to 2022 (2)

	Unit	2018	2019	2020	2021	2022
Energy management						
Energy consumption						
Energy consumed (absolute)	GJ[10]	1,111,299	1,143,883	803,990*	847,643*	**896,147***
Direct energy consumption	GJ	44,410	39,457	19,719*	18,329*	**20,135***
Indirect energy consumption	GJ	1,066,889	1,104,426	784,271*	829,314*	**876,012***
Direct energy consumed by type						
Diesel	Litres	1,092,912	967,139	450,404*	417,672*	**483,650***
Petrol	Litres	114,362	107,268	87,757*	81,939*	**64,392***
LPG	Litres	20,233	16,031	12,434*	11,779*	**11,158***
Indirect energy consumed						
Electricity consumed (absolute)	kWh ('000)	296,358	306,785	217,853*	230,365*	**243,337***
Water management[11]						
Municipal water consumed (absolute)	m^3 ('000)	380	353	340*	206*	**148***
Water withdrawal by other sources						
Seawater[12]	m^3 ('000)	77,521	81,682	63,069*	63,132*	**73,432***
Water recycled/reused	m^3 ('000)	163	173	168	301	**147**
Water discharge						
Total water discharge[13]	m^3 ('000)	217	180	172*	(95)*	**1***
Aircraft fuel spillage						
Aircraft fuel spillage	Number of spills	16	9	9	16	**14**

Figure 5. HKIA Environmental Data from 2018 to 2022 (3)

The data underscores a pronounced reduction in GHG emissions across all scopes in 2020, a consequence of the pandemic's impact and the ensuing decrease in operations and activities. While some areas exhibit signs of recovery in subsequent years, emissions largely remain below pre-pandemic benchmarks. Stationary emissions have consistently diminished over time, suggesting either enhanced efficiency or scaled-back operations. Mobile emissions also plummeted in 2020, with a modest resurgence in 2022, yet they haven't reached their pre-pandemic figures. Similarly, emissions from electricity witnessed a sharp decline in 2020 due to curtailed operations, and though there's been a gradual uptick since 2022, it's still not back to its former levels.

Travel restrictions and operational cutbacks during the pandemic led to a significant decrease in emissions from staff business travel and surface movement of passengers and staff in 2020 and 2021. Waste disposal emissions and energy consumption by tenants also saw marked

ISSN: 2637-6067 DOI: 10.6918/IJOSSER.202312_6(12).0008

reductions during this period. However, 2022 recorded slight increases in these categories, albeit still not matching pre-pandemic levels.

Total energy consumption followed a similar trajectory, with a major drop in 2020 and a steady rise thereafter, yet not reaching previous levels. This pattern is evident in both direct and indirect energy consumption. Notably, diesel, as a direct energy source, experienced the most substantial decline during the pandemic. Electricity consumption, an indirect source, mirrored this trend. Water management was also impacted. Municipal water consumption has been on a consistent decline, with the pandemic years accentuating this trend. While seawater withdrawal dipped in 2020, it stabilized in 2021 and saw an uptick in 2022, hinting at a potential operational rebound. A noteworthy observation is the significant increase in water recycled/reuse in 2021, possibly indicative of conservation initiatives. Conversely, water discharge has been on a downward trend, and the number of fuel spills, after decreasing in 2019 and 2020, rose in 2021, suggesting potential operational challenges.

The pandemic has had a profound impact on the environmental footprint of operations, leading to substantial reductions in emissions, energy, and water consumption in 2020. While there are indications of recovery in certain areas in the subsequent years, the overarching theme is one of reduced environmental impact, with most metrics still lagging behind their pre-pandemic levels.

3.2. Low-carbon operating models

Despite pandemic-induced disruptions, the Airport Authority Hong Kong (AAHK) has persistently advanced its sustainability initiatives. Drawing from official newsletters, by January 2020, HKIA had broadened its ISO 50001 Energy Management System certification to encompass all terminal buildings, underscoring its dedication to energy performance enhancement [3]. In a significant move in April 2020, AAHK initiated a study to establish a 15-year airport-wide carbon reduction goal, named "The Net-Zero Carbon Emissions." [3] Building on prior endeavors, HKIA revealed its ambitious plan to achieve Net Zero Carbon by 2050, setting an interim target to curtail absolute emissions by 55% by 2035, using 2018 as the reference point [3]. This aligns with HKIA's overarching vision of evolving into a low-carbon airport, having already rolled out over 400 carbon reduction initiatives [1]. These efforts, in collaboration with regional partners, aim to bolster airport resilience against climate change and underscore long-term carbon commitments. To realize these goals, AAHK is implementing measures like airside vehicle electrification, energy-efficient installations, and pioneering energy management systems.

On the operational front, HKIA has been proactive. Initiating an electric vehicle replacement program for the airport's restricted area in 2013, by 2017, all caravans transitioned to electric vehicles [1]. This was complemented by a ground handling equipment sharing program in 2018, with 95% of the 250 equipment sets being electric [1]. This not only curtails carbon emissions but also mitigates tarmac congestion. The program's second phase, set for April 2022, will expand its reach to Terminal 1's apron, nearly doubling the equipment count to 580 units [9].

In line with its sustainability vision, Terminal 2 underwent a closure for eco-friendly refurbishment in November 2019 [10]. Its anticipated reopening in 2024 promises significant energy savings, with the revamped Terminal 2 and the new T2 Passenger Concourse projected to conserve 45,000 kWh of electricity annually, thereby preventing the emission of 17,500 metric tons of carbon dioxide equivalent [10].

4. Discussion

The COVID-19 pandemic has undeniably reshaped the operational landscape of HKIA, with its effects palpably evident in both economic and environmental metrics. The downturn in

ISSN: 2637-6067 DOI: 10.6918/IJOSSER.202312_6(12).0008

2020/21, induced by the pandemic, led to a marked decrease in passenger traffic, aircraft movement, and revenue. Paradoxically, this economic setback inadvertently resulted in a significant reduction in GHG emissions across all scopes. The reduced operations, accentuated by travel restrictions, led to decreased emissions from staff business travel, surface movement of passengers and staff, and waste disposal. Moreover, the consistent decline in stationary emissions and the pronounced drop in mobile emissions in 2020 suggest that the pandemic's effects complemented HKIA's low-carbon initiatives.

Throughout the pandemic, HKIA's commitment to sustainability remained unwavering, even in the face of unparalleled challenges. Notably, in 2020/21, despite the revenue slump, operating costs rose. This could indicate potential inefficiencies or unavoidable fixed costs, but it also underscores AAHK's continued dedication to its sustainable development goals, as evidenced by the expansion of its ISO 50001 Energy Management System certification and the sustainability-focused refurbishment of Terminal 2.

From an environmental perspective, the pandemic inadvertently expedited HKIA's sustainability trajectory. The significant reductions in energy consumption, both direct and indirect, coupled with the decline in water consumption, underscore the reduced environmental footprint of the airport's operations during the pandemic. The increase in water recycling in 2021 further emphasizes HKIA's unwavering commitment to sustainability. While these reductions might initially seem beneficial for sustainability, they are primarily a result of decreased airport activities rather than strategic sustainability initiatives. The resurgence in some metrics in 2022, though still below pre-pandemic levels, suggests a gradual return to normalcy.

The data provided suggests a dual impact on HKIA's environmental metrics. On one hand, the reduction in flights and passenger traffic due to the pandemic has undoubtedly led to decreased carbon emissions. This involuntary operational contraction had a short-term positive effect on the environment. Conversely, HKIA's deliberate low-carbon strategies promise a more enduring reduction in its carbon footprint. Initiatives like the transition to electric vehicles, the adoption of energy-efficient installations, and the eco-centric overhaul of Terminal 2 are strategic endeavors with long-term environmental benefits. Collectively, these measures, in alignment with HKIA's overarching ambition of evolving into a low-carbon hub, showcase a systematic and strategic commitment to sustainability.

5. Conclusion

This study's comparative analysis of the low-carbon operations at HKIA before and after the pandemic has illuminated the multifaceted impacts of such an unprecedented event. Before the pandemic, HKIA was on a clear trajectory towards sustainability, investing in low-carbon initiatives and strategies that promised a greener future. However, the pandemic brought about an involuntary reduction in operations, leading to decreased carbon emissions, albeit primarily due to reduced airport activities rather than strategic sustainability measures.

In future research endeavors, the analytical approach can be enhanced by incorporating advanced models to rigorously examine the interrelationships between operational, economic, and environmental metrics. This study primarily focused on direct impacts, potentially overlooking certain external factors that might have influenced the environmental data during 2020/21. Recognizing these factors and integrating them into subsequent analyses would offer a more holistic understanding of the pandemic's multifaceted impact on airport operations.

Yet, even amidst the challenges, HKIA's commitment to sustainability remained unwavering. Through strategic initiatives and forward-thinking measures, HKIA is not only reducing its carbon footprint but also paving the way for a more sustainable aviation industry. HKIA

ISSN: 2637-6067 DOI: 10.6918/IJOSSER.202312_6(12).0008

demonstrated resilience and adaptability, emphasizing the importance of strategic planning in the face of global adversities.

References

[1] Airport Authority Hong Kong. (2020). Sustainability Report 2019/20. Retrieved from https://www.hongkongairport.com/iwov-resources/file/sustainability/sustainability-report/AA_Sustainability_Report_201920_ENG.pdf

[2] Airport Authority Hong Kong. (2019). Sustainability Report 2018/19. Retrieved from https://www.hongkongairport.com/iwov-resources/html/sustainability_report/eng/SR1819/index.html

[3] Airport Authority Hong Kong. (2021). Sustainability Report 2020/21. Retrieved from https://www.hongkongairport.com/iwov-resources/file/sustainability/sustainability-report/AA_Sustainability_Report_202021_ENG.pdf

[4] Tsui, K. W. H., Fu, X., Chen, T., Lei, Z., & Wu, H. (2021). Analyzing Hong Kong's inbound tourism: The impact of the COVID-19 pandemic. IATSS Research, 45(4).

[5] Allen, M. (2019). Flying Green: The Low-Carbon Airport of Tomorrow. Jscholarship.library.jhu.edu.

[6] Qiu, R., Hou, S., & Meng, Z. (2021). Low carbon air transport development trends and policy implications based on a scientometrics-based data analysis system. Transport Policy, 107, 1–10.

[7] Sun, X., Wandelt, S., & Zhang, A. (2022). COVID-19 pandemic and air transportation: Status quo of the paper hurricane and how to proceed further? Transportation Research Interdisciplinary Perspectives, 16, 100718.

[8] Hemmings, P., Mulheron, M., Murphy, R. J., & Prescott, M. (2021). Investigating the Impact of COVID-19 Disruption on the Decarbonisation Agenda at Airports: Grounded or Ready for Take-Off? Sustainability, 13(21), 12235.

[9] Airport Authority Hong Kong. (2023). Sustainability Report 2022/23. Retrieved from https://www.hongkongairport.com/iwov-resources/file/sustainability/sustainability-report/AA_Sustainability_Report_202223_ENG.pdf

[10] Airport Authority Hong Kong . (2022). Sustainability Report 2021/22. Retrieved from https://www.hongkongairport.com/iwov-resources/file/sustainability/sustainability-report/AA_Sustainability_Report_202122_ENG.pdf