

Challenges and Barriers to Green airport development in Vietnam: Assessment of current situation and Recommendations

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ABSTRACT

In the context of the global aviation industry facing intense pressure from commitments to reduce greenhouse gas emissions and the demand for sustainable development, the transition to green airport models in Vietnam has become more urgent than ever. However, this process is encountering significant challenges and barriers. This paper examines the primary obstacles to green airport development in Vietnam through a field survey conducted at 22 airports, focusing on issues related to legal frameworks, financial resources, management capacity, technical infrastructure, technology, and multi-stakeholder coordination mechanisms. The results show that Vietnam's airport system currently meets only basic environmental compliance requirements, with a low and inconsistent level of integration of green solutions, particularly at smaller and regional airports. Based on these findings, the paper proposes several policy recommendations to address barriers and promote the green transition process, aiming for sustainable development and carbon neutrality by 2050.

Keywords: green airport, carbon neutrality, net Zero, Vietnam aviation.

1. INTRODUCTION

The global aviation industry is facing pressure to reduce greenhouse gas (GHG) emissions, aiming for carbon neutrality by 2050, in line with ICAO recommendations and international commitments. Globally, GHG emissions from the aviation sector account for approximately 2.5% of total CO₂ emissions and contribute about 4% to global warming [1]. The increase in passenger and cargo traffic amidst climate change (CC) and the demand for sustainable development (SD) challenge airports worldwide to shift their development model from “hot growth” to “green growth”.

In Vietnam, the growth rate of air passengers and cargo over the past decade has consistently been high, especially with the emergence of key projects such as Long Thanh airport. The average annual growth rate for air passenger and cargo throughput during the 2020-2024 period is 26.8% and 28.2%, respectively [2]. Therefore,

Vietnam's aviation industry is facing the requirement to transition to a green airport model to ensure sustainable development. However, this process encounters numerous economic, technical, legal, and social barriers. In this context, researching the barriers to green airport development in Vietnam holds significant theoretical and practical importance. It not only helps identify existing economic, legal, technical, and social challenges but also provides a scientific basis for proposing appropriate solutions, ensuring the national commitment to carbon neutrality by 2050. Furthermore, this study contributes to clarifying the gap between policy orientation and implementation capacity, thereby promoting coordination among the State, enterprises, and stakeholders in the aviation industry's green transition process.

The concept of green airports has been introduced by organizations to encourage countries to implement environmentally friendly practices, aiming for sustainable development and carbon neutrality. The

Airports Council International (ACI) defines: “A green airport is an airport that applies environmentally friendly practices throughout the entire process of design, construction, operation, and maintenance, aiming to reduce emissions and negative environmental impacts [3]. The International Civil Aviation Organization (ICAO) introduces the concept of sustainable airport: “Sustainable airport operations include measures aimed at reducing the environmental footprint of airport activities through the management of energy, water, waste, air quality, biodiversity, and noise” [4]. Meanwhile, the International Air Transport Association (IATA) encourages: “Green airport development is part of the broader sustainable development goal, achieved through optimizing the efficiency of energy, water, and resource use, while enhancing passenger experience and minimizing ecological impact” [5].

In the trend of modern aviation development, many countries such as Germany, United State, England, Singapore and South Korea have converted their airports to a green model to minimize environmental impact. Some typical airports in the world such as Singapore Changi Airport (SIN), Hamad International Airport (DOH), Amsterdam Schiphol Airport (AMS), San Francisco International Airport (SFO), Zurich Airport (ZRH),... as shown in Figure 1. In which, SIN airport is a pioneering eco-airport model, integrating sustainable principles into design, operation and development [7-10]; DOH airport prioritizes sustainable architecture

with natural light, recycled materials and insulated roofs, reducing the need for air conditioning in hot climates [11-14]; AMS airport uses 100% renewable electricity from wind and solar, deploys solar power systems on the roof of the terminal and cooperates in investing in offshore wind farms [15-18]; SFO airport uses 100% renewable electricity from solar, wind and hydropower, applying Net-Zero Energy standards for new buildings, combining sensor LEDs and inverter air conditioning. SFO pioneers the use of 100% recycled water for cooling, sanitation and landscape irrigation, along with a rainwater collection system and water-saving equipment. Waste management aims for zero landfill, waste separation, recycling of building materials and elimination of single-use plastics [19-22]. ZRH airport invests heavily in renewable energy with a biomass plant, solar power systems and Minergie-standard building design, combining advanced insulation, LEDs and inverter air conditioning. Regarding water, ZRH collects rainwater, reuses wastewater and maintains green landscapes with native plants, increasing biodiversity. The airport manages waste according to a circular model, sorting at the source, recycling organic waste and building materials [23-26]. In summary, typical ports prioritize the use of renewable energy (solar power, wind power), smart water management, effective waste treatment and biodiversity conservation. At the same time, digital technology, automation and environmentally friendly vehicles are widely applied to improve operational efficiency.



a) Hamad International Airport (DOH)



b) Amsterdam Schiphol Airport (AMS)



c) Francisco International Airport (SFO)



d) Zurich Airport (ZRH)

Figure 1. Some typical airports in the world

The concept of a green airport is not merely a theoretical idea but is shaped by international standards regarding design, operation, and environmental management. The three most typical and influential systems currently used to evaluate green airports are: 1) Airport Carbon Accreditation (ACA); 2) Environmental management systems: ISO 14001, ISO 50001, ISO 46001; 3) LEED and BREEAM green building are described as Figure 2.



Figure 2. Integrated Program Cluster within the Green Airport Criteria System

Among these, Airport Carbon Accreditation (ACA), developed by ACI since 2009, is the only program that evaluates and promotes CO₂ emission reduction at airports, complying with international standards such as GHG Protocol, ISO 14064-3:2019, and IWA 42:2022. ACA focuses on CO₂ – the type of GHG that accounts for the largest proportion of airport emissions [3]. Conversely, LEED and BREEAM are widely applied green building certification systems. LEED and BREEAM focus on evaluating energy efficiency, water usage, sustainable materials, and indoor

environment, supporting airports in developing comprehensive green infrastructure [6]. Furthermore, ISO standards such as ISO 14001 (environmental management), ISO 46001 (water management), and ISO 50001 (energy management) serve as governance tools, helping to establish mechanisms for continuous control and improvement.

Thus, combining all three evaluation systems helps airports not only meet ICAO’s carbon reduction requirements but also build a comprehensive green infrastructure model.

2. MATERIALS AND METHODS

2.1. Current Status of Environmental Management and Quality at Airports in Vietnam

2.1.1. Approach to Assessing the Current Status of Environmental Management and Quality at Airports

A method combining field surveys and the synthesis of reported data from 22 airports was used in this study. Specifically, survey questionnaires were developed to collect multi-dimensional information regarding policies, management organization, technical operation, environmental indicators, and solutions implemented at the airports. The collected data was processed using descriptive statistics, standardized into quantitative indicators, and qualitative content was coded.

2.1.2. Current Status of Environmental Management and Quality at Airports

Based on the survey results at 22 airports

in Vietnam in 2024, the current status of environmental management and quality at these airports is summarized as follows:

Energy Consumption Demand:

The energy consumption demand at the surveyed airports is shown in Figure 3.

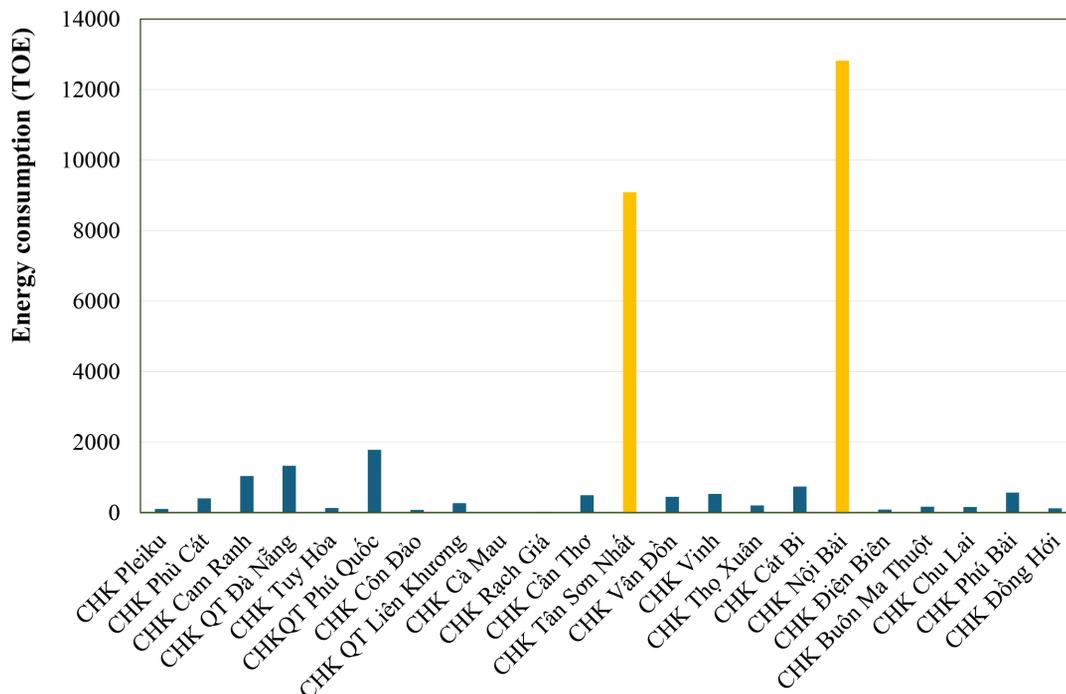


Figure 3. Energy Consumption Demand in 2024 at Surveyed Airports

The electricity consumption chart (TOE) shows a clear disparity among Vietnam’s airports. Noi Bai and Tan Son Nhat lead with over 12,000 and 9,000 TOE, reflecting their large operational scale. Da Nang, Cam Ranh, and Phu Quoc have high passenger volumes but lower electricity consumption, indicating differences in design and energy management. Local airports such as Ca Mau, Chu Lai, and Dong Hoi are below 500 TOE, consistent with their small scale. This data indicates a correlation between operational scale and electricity consumption level, while also emphasizing the need to analyze the average consumption per passenger index to evaluate energy efficiency.

Currently, the national grid electricity still accounts for the largest proportion of the total energy demand at airports, especially at major airports, serving lighting systems, air conditioning, ground equipment operation, and auxiliary services. Furthermore, fossil fuels such as diesel and gasoline are still commonly used for ground transportation vehicles, backup generators, and certain technical

systems, accounting for approximately 15–25% of the total energy demand. Meanwhile, renewable energy sources such as solar and wind power have only been implemented on a very small scale, primarily remaining at the pilot or planning stage, accounting for less than 5% of the total energy consumed. This heavy reliance on grid electricity and fossil fuels not only increases operating costs but also puts significant pressure on the aviation industry’s GHG emission reduction goals. This situation indicates great potential for diversifying energy sources, increasing the proportion of clean energy, and promoting solutions for energy saving and efficient use at Vietnam airports in the near future.

Environmental protection technical infrastructure:

Solid waste management: Most airports have implemented source separation and collection systems for solid waste, primarily divided into household waste and hazardous waste. However, the classification remains rudimentary, failing to separate plastic, organic, or recyclable waste, which reduces recycling

potential and prevents the environmental benefits of waste from being utilized. The reuse of treated wastewater is also not yet common; only Noi Bai has implemented this, while other airports primarily focus on ensuring discharge meets standards.

Water management: All centralized wastewater treatment plants operate according to QCVN standards, ensuring the quality of effluent water. However, the reuse of wastewater for secondary purposes such as watering plants or washing runways remains limited. Rainwater collection systems have been invested in by most enterprises, contributing to the reduction of flooding.

Air quality management: Automatic air quality monitoring systems have not been synchronously installed across the entire system. Most enterprises primarily conduct periodic monitoring as required by law. The electrification of Ground Support Equipment (GSE) is still limited; only a few enterprises have converted over 50%, while the majority still use diesel-powered vehicles.

Noise management: Investment in noise reduction systems such as soundproofing walls and coordinating takeoff and landing time slots has been prioritized, but most enterprises have only invested partially, and the number of enterprises with full investment remains limited.

Application of green technology and energy saving solutions:

The adoption of smart energy management systems (BMS/EMS) is limited, with only about 20% of enterprises fully implementing them, and over 50% having not yet deployed them. Energy-saving LED lighting systems have been partially or fully installed in terminal areas, parking lots, and taxiways, but only 30% of enterprises have adopted them entirely. Investment in renewable energy remains very modest, mostly staying at the planning stage, with only a small number of enterprises having actual implementation.

Attention has been paid to Heating,

Ventilation, and Air Conditioning (HVAC) automation systems, with 50% of units already having automation systems and 12% currently building them. However, the procurement of electricity from renewable energy sources and cooperation in using Sustainable Aviation Fuel (SAF) remain very limited.

Management and reduction of Greenhouse Gas emissions:

GHG emission reduction solutions such as the electrification of ground support equipment, replacing the entire lighting system with LEDs, installing on-site renewable energy, using energy-efficient HVAC systems, optimizing logistics operations, etc., are mostly at the planned application or ongoing deployment stage, with a low rate of actual adoption. GHG emission inventories are primarily focused on large airports like Noi Bai and Da Nang, while smaller airports have very limited carbon management capacity.

General assessment:

Overall, the Vietnam's airport system only meets basic environmental compliance requirements; the level of integration of sustainable solutions and advanced technology is low and lacks synchronization. The significant gap between major and local airports poses a challenge in synchronizing the green airport development process.

3. RESULTS AND DISCUSSION

The Vietnam's aviation industry is under significant pressure from GHG emission reduction targets recommended by ICAO and the Net Zero 2050 commitment. The main current difficulties and barriers for Vietnam airports pursuing comprehensive greening objectives are as follows:

3.1. Limitations regarding the legal framework and national standards

One of the biggest barriers to the development of green airports in Vietnam is the lack of a specialized set of national criteria and standards for this sector. Currently, airports primarily reference international standards such as ACA (Airport Carbon

Accreditation), ISO 14001, ISO 50001, LEED, BREEAM, or LOTUS, but the localization and institutionalization of these standards remain slow, leading to inconsistency in implementation and evaluation. The absence of mandatory regulations on green criteria means that greening activities are mostly voluntary, lacking motivation and effective monitoring mechanisms. Furthermore, legal regulations concerning the management of environmental quality, waste, water, noise, and greenhouse gas emissions are fragmented and have not been integrated into a comprehensive legal framework, causing difficulties for businesses during implementation and compliance.

3.2. Lack of financial resources and investment support mechanisms

Developing green airports requires significant investment capital for items such as renewable energy, smart energy management systems (BMS/EMS), energy-saving equipment, wastewater treatment, waste sorting and recycling, as well as international standard green buildings. However, green financing mechanisms, preferential credit, green bonds, or support from environmental protection funds are limited in scale and involve complex access procedures. In particular, local and small-scale airports face major difficulties in mobilizing investment capital due to low revenue and long payback periods. The lack of preferential policies regarding taxes and fees, as well as Public-Private Partnership (PPP) risk-sharing mechanisms, weakens the incentive to invest in green projects. This creates a legal vacuum, forcing airport operators to self-reference international standards such as LEED, BREEAM, or ACA, which have not yet been localized.

3.3. Limitations regarding governance capacity and human resources

Practical surveys indicate that the majority of airports in Vietnam have not yet established an Environmental Management System (EMS) compliant with ISO 14001, lacking specialized departments and personnel with expertise in

environmental, energy, and greenhouse gas emissions management. Emissions inventory, developing emission reduction plans, setting environmental KPIs, and operating the MRV (Measurement, Reporting, Verification) system remain largely formalistic, lacking quantitative data and independent verification. Training, internal communication, and raising awareness about sustainable development are also limited, resulting in the implementation of green solutions primarily based on administrative directives, lacking initiative and innovation at the grassroots level.

3.4. Inconsistent technical infrastructure and technology

The majority of existing airports were constructed decades ago and did not integrate green technology solutions from the outset. Renovation and upgrading to meet green criteria face numerous difficulties due to space constraints, high investment costs, and the risk of disrupting operational activities. Energy management systems, LED lighting, energy-saving HVAC, electrification of Ground Support Equipment (GSE), wastewater treatment systems, source separation of waste, and digitized environmental management technology have only been deployed at a few large airports, while most small and local airports still operate under traditional models, resulting in low resource efficiency and high emissions. The application of new technologies such as IoT, AI, digital twin, and smart monitoring systems remains very limited.

3.5. Lack of multi-stakeholder coordination and monitoring mechanism

Environmental management at airports is an interdisciplinary field, requiring close coordination among state management agencies, airport operators, airlines, ground service providers, construction units, local communities, and international organizations. However, the current coordination mechanism remains loose, lacking clear regulations regarding responsibilities, authorities, and data sharing mechanisms among the parties.

The Monitoring, Reporting, and Verification (MRV) system has not been synchronously established, leading to a lack of transparency and difficulty in truly assessing the effectiveness of greening programs. The disclosure of environmental information, sustainable development reports, and community consultation remain formalistic, failing to create continuous pressure for improvement and build social trust.

3.6. Challenges from climate change and adaptation requirements

Climate change increases the frequency of extreme weather phenomena such as heavy rain, flooding, and prolonged heatwaves, directly affecting airport infrastructure, operation, and safety. However, most airports in Vietnam have not fully integrated climate adaptation solutions into their planning, design, and operation. Climate risk assessment, development of response scenarios, upgrading resilient infrastructure, and biodiversity conservation lack systematic implementation and have not been prioritized in the allocation of investment resources.

4. CONCLUSION

By using a combination of field survey methods, synthesis, and analysis of reported data at 22 airports nationwide, the study assessed the current status of environmental management and the level of implementation of green solutions at Vietnamese airports. The results show that most airports only meet basic environmental compliance requirements, and the level of integration of sustainable solutions remains low, especially at smaller and local airports.

The study also clearly identified major difficulties and barriers to the development of green airports in Vietnam, such as: lack of a specialized legal framework and national standards, limited financial resources, weak governance capacity and human resources, unsynchronized technical infrastructure and technology, inefficient multi-stakeholder coordination mechanisms, along with challenges from climate change. These

barriers not only slow down the greening process but also create a significant gap between policy orientation and practical implementation. The aforementioned barriers indicate that developing green airports in Vietnam is a complex process, requiring synchronization from perfecting the legal framework, increasing financial resources, enhancing governance capacity, investing in technology, to establishing transparent coordination and monitoring mechanisms. To overcome these challenges, strong involvement from the State is needed in issuing national standards, designing green financial mechanisms, supporting human resource training, promoting technology transfer, and strengthening international cooperation. Concurrently, airport operating enterprises need to proactively develop sustainable development strategies, integrate green criteria into all activities, and ensure information transparency to build trust with the community and investors. The synchronized implementation of solutions will contribute to removing barriers, accelerating the green transition process, enhancing competitiveness, and ensuring sustainable development for Vietnam's aviation industry.

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