

# The Transformation of the Green Sustainable Airports Construction Industry Through the Innovative Applications of Green Energies in Comprehensive Energy Modality of "Venus": A Study on the Supply & Development of Renewable Energy in Airports of Country with Dry Climate by Means of Wind & Solar Energy

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## ABSTRACT

This article highlights a modern airport in the Middle East that utilizes renewable energy sources, namely wind and solar power, to meet its entire energy requirements. The airport implements an innovative energy system, harnessing wind energy during cloudy days and solar energy from solar cell panels on sunny days. By relying on renewable energy exclusively, the airport contributes to environmental sustainability and reduces its carbon footprint. It provides an overview of the airport's adoption of clean energy technologies, emphasizing its commitment to a greener and more sustainable future in the aviation sector.

The share of renewable energy sources use has not kept up with the increase in energy demand. As a result, more and more conventional energy sources are used and in this case lignite which is an indigenous source of energy and natural gas.

This energy picture leads towards a greater environmental impact due to the increase of pollutants to the atmosphere. Renewable energy sources could cover a major part, if not all, of all airport needs, following the promising results of the recent renewable energy sources exploration in the region. In this work and optimization model has been developed to determine the optimum share of renewable energy sources in various end-uses such as heating, cooling, and lighting. In this model the reliability and environmental parameters were taken into consideration. The renewable energy sources include solar energy, geothermal energy and biomass.



Schematic of the exterior space of an airport in a region with a dry climate, which is powered by solar cells (on sunny days) and wind energy (on cloudy days).

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## Introduction

This article explores the innovative and sustainable approaches implemented by a modern airport in the Middle East to meet its energy demands entirely through renewable sources. By harnessing the power of wind and solar energy, this airport has set an exemplary model for the aviation industry to mitigate its environmental impact. The case study highlights the integration of wind energy on cloudy days and solar energy from solar cell panels on sunny days, demonstrating the airport's commitment to reducing its carbon footprint.

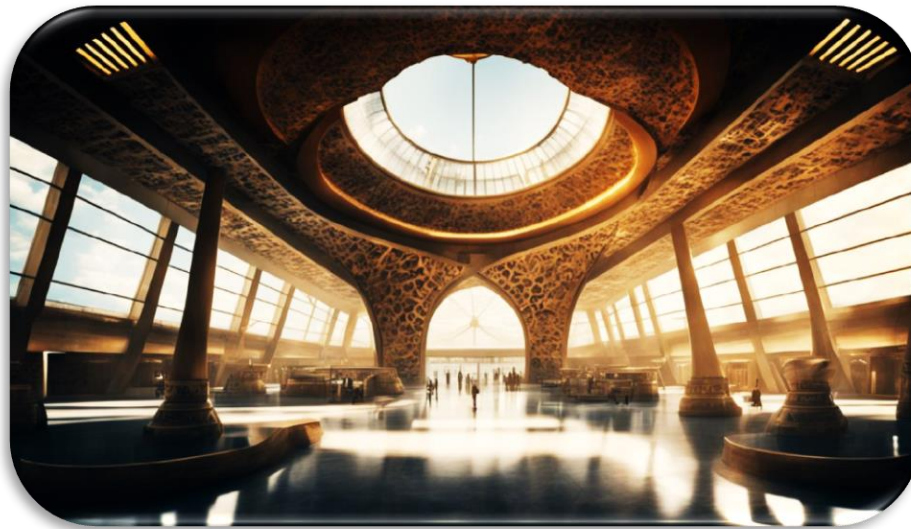
Airports serve as vital hubs of transportation, connecting people and businesses across the globe. However, the rapid growth of the aviation industry has raised concerns regarding its significant carbon emissions and contribution to climate change. Addressing these concerns, one pioneering airport in the Middle East has taken a bold step towards sustainability by becoming energy self-sufficient

through renewable sources. This article highlights the airport's use of wind energy on cloudy days and solar energy from solar cell panels on sunny days as an exemplary model for eco-friendly airport operations.

## Discussion

### Harnessing Wind Energy

The airport's sustainable energy journey embraces the strength of nature, capitalizing on the region's strong winds on cloudy days. Multiple wind turbines have been strategically installed around the airport's vicinity to harness wind energy even during suboptimal weather conditions. These turbines generate electricity, which is directly fed into the airport's power grid. Advanced technology and accurate wind data analysis contribute to an efficient utilization of this renewable resource. By relying on wind energy during cloudy days, the airport reduces its dependence on non-renewable energy sources and decreases its carbon emissions substantially.



**Figure2:** Schematic of the interior space of an airport in a region with a dry climate, which is powered by solar cells (on sunny days) and wind energy (on cloudy days).

### Embracing Solar Power

On sunny days, when the relentless Middle Eastern sun graces the region, the airport maximizes the utilization of solar energy. A vast

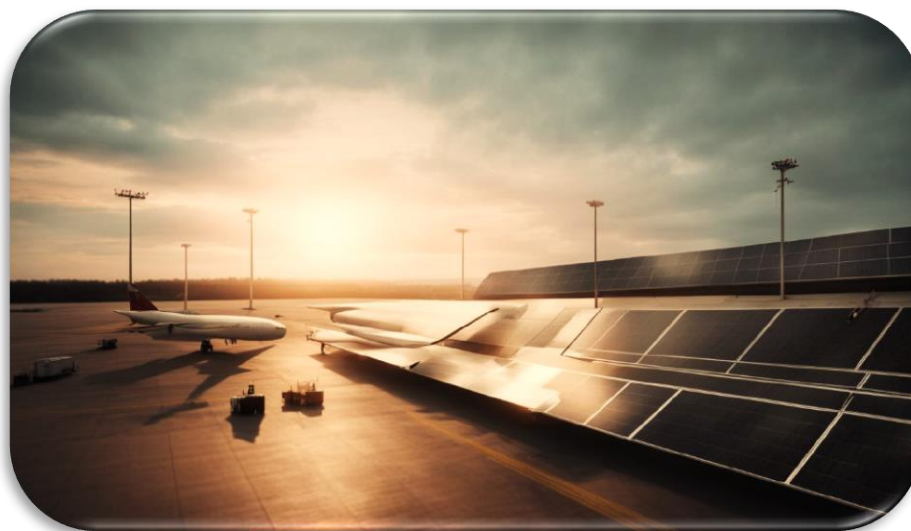
array of solar cell panels covers the airport's rooftops, parking lots, and unused land. These panels capture the sun's energy and convert it into electricity that can power various airport

operations. By integrating this clean, abundant energy source, the airport significantly reduces its reliance on traditional power grids, minimizing its environmental impact and promoting sustainability throughout its infrastructure.

### Energy Storage and Efficiency

To ensure a continuous and reliable power supply, the airport has implemented an advanced energy storage system. Excess energy generated from wind and solar sources is stored

in batteries, which are then used during periods of low energy production. This efficient energy storage system ensures a consistent and uninterrupted power supply, essential for maintaining the airport's operations. Additionally, the airport has incorporated energy-efficient technologies into its facilities, including LED lighting systems, efficient cooling and heating systems, and smart energy management systems, further enhancing its sustainability practices.



**Figure3:** Schematic of the exterior space of an airport in a region with a dry climate, which is powered by solar cells (on sunny days) and wind energy (on cloudy days).

## Benefits

### Benefits and Lessons Learned

The success of this airport's renewable energy initiatives extends beyond its positive environmental impact. By reducing its dependence on traditional power sources, the airport has experienced significant cost savings, leading to improved operational efficiency. The implementation of renewable energy technologies has also enhanced the airport's reputation, attracting environmentally conscious businesses, airlines, and travelers. This holistic approach not only benefits the

airport itself but also contributes to the country's broader sustainability goals.

In the past decade or so, the operating environment for airports has undergone significant changes. The rise in the number of travelers has led to an increase in the energy demands of airports worldwide. Simultaneously, the global demand for energy has been rapidly growing, especially from emerging economies like China and India. Consequently, the cost of electricity for airports has seen a considerable escalation.

The emission of greenhouse gases and air pollutants from power generation and fossil fuel combustion has a detrimental impact on climate

change, with these emissions being the major contributor to global warming. These interlinked energy and environmental factors have placed immense economic and political pressure on airport administrations to reduce energy consumption and minimize their carbon footprint. Airport buildings play a crucial role in energy usage due to their architectural and structural characteristics, such as large glass windows and high ceilings, along with continuous movement of large groups of people. As the number of passenger's increases, so does energy usage, especially electricity. Moreover, during peak periods like Christmas and summer vacations, airports need to service a greater number of people in a short span of time. This can pose challenges to the local electricity network, particularly if it is an isolated (island) network. As a result, efficient electricity management becomes of paramount importance.

To address these challenges, many airports worldwide have started utilizing renewable energy sources (RES). For instance, Boston Airport has installed its wind farm, generating around 100,000 kWh annually, which accounts for approximately 2% of the airport's monthly energy consumption. Denver International Airport has implemented a solar photovoltaic system generating 3 million kWh of electricity per year. Philadelphia International Airport has made plans to purchase clean wind energy, offsetting over 14 million pounds of carbon dioxide emissions and equivalent to the electricity consumption of more than 1300 typical homes.

Brussels Airport is also actively installing RES to cover a part of its energy needs and reduce CO<sub>2</sub> emissions. Their efforts include the use of biofuels, biomass and bio-CHP systems, energy crops, energy recovery from organic waste, underground cold/warm storage, photovoltaic cells, and wind energy.



**Figure4:** *Schematic of the exterior space of an airport in a region with a dry climate, which is powered by solar cells (on sunny days) and wind energy (on cloudy days).*

A hybrid renewable energy system that combines solar and wind energy sources, along with a backup generator, is being designed and simulated for Mwanza International Airport in Tanzania, which expects to consume approximately 18 MVA of electric power

annually. The proposal aims to capitalize on the region's plentiful solar irradiation and wind speed to generate electricity via solar photovoltaic panels and a 10-kW wind turbine. Additionally, a diesel generator and battery are incorporated to address intermittency issues.

The project, with a lifespan of 25 years, proves cost-effective given the potential energy output of 18 MVA, meeting the load requirements of Mwanza International Airport.

Overall, the implementation of a mixed-coupled hybrid renewable energy source for airports is essential, considering the reliability of electric energy required to support airport operations. Most importantly, shifting towards renewable energy sources mitigates global warming and helps reduce greenhouse gas emissions associated with conventional power generation methods. Mathematical computations and simulation results play a crucial role in determining the optimal techno-economic configurations for hybrid renewable energy systems at airports.

The complete design of the selected system includes a 78.48 kW photovoltaic (PV) system consisting of 314 poly-crystalline modules with a power output of 200 W each, 608 batteries with a rating of 83.4 Ah and a voltage of 12 V, a 140 kVA diesel generator, and a bidirectional converter with a capacity of 41.64 kVA. The net present cost of this design is US\$357,780.8, the

energy cost is estimated at 0.93 US\$/kW, and the minimum renewable fraction is 40.2%.

Currently, the aviation industry is a major contributor to greenhouse gas emissions. To address this issue, substituting conventional electricity consumption with clean energy sources is considered an optimal solution. Airports often have barren lands available as buffer zones, which can be utilized for generating electricity from clean energy sources like solar and wind. This study proposes the establishment of a 5 MW grid-connected solar power plant at airport sites, utilizing the substantial barren areas. The energy efficiency varies from 18.74% to 7.79% for Shah Amanat International Airport and from 17.71% to 7.45% for Hazrat Shahjalal International Airport. The project outcome indicates that investing the total cost in power plants rather than keeping it in the bank as a deposit would yield 25% higher revenue. Furthermore, the emission analysis shows a potential reduction of 3827.5 tons of CO<sub>2</sub>/MWh for Shah Amanat International Airport and 3926 tons of CO<sub>2</sub>/MWh for Hazrat Shahjalal International Airport.



**Figure5:** Schematic of the exterior space of an airport in a region with a dry climate, which is powered by solar cells (on sunny days) and wind energy (on cloudy days).

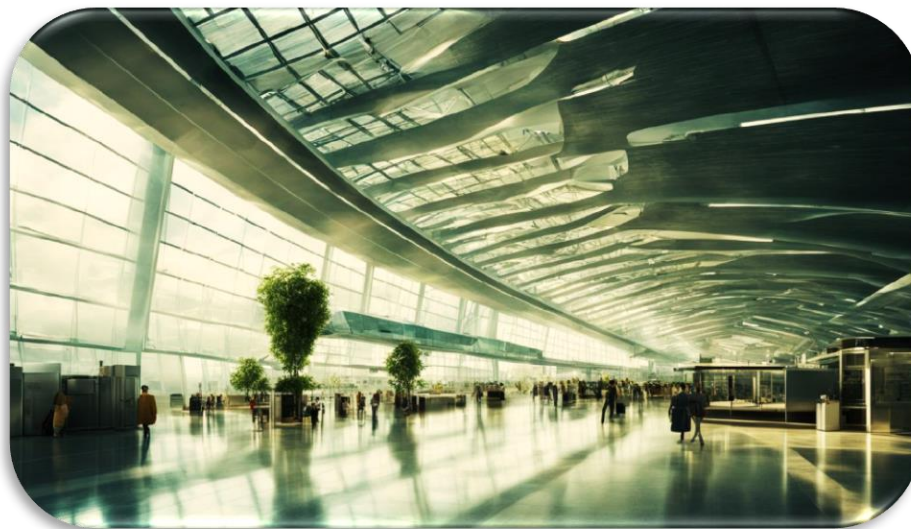
Sustainability analysis reveals the energy depletion ratios for Shahjalal Airport ranging

from 0.82 to 0.93 and for Shah Amanat Airport ranging from 0.81 to 0.92. The findings suggest

that investment in grid-connected solar power plants is both economically viable and environmentally friendly.

The significant increase in atmospheric carbon dioxide concentration, amounting to 40% over the last 250 years (from 280 ppm in 1750 to 400 ppm in 2015), is a global concern due to its greenhouse gas effects. The aviation industry has been a consistent contributor to these emissions. Currently, aviation exhaust gas accounts for 3.5% of global emissions, and this share is projected to double within the next 15 years. India, with its abundant solar irradiation and sunny days, is in a favorable position to reduce its greenhouse gas emissions under the

Conference of the Parties (COP) agreement in Paris, France. The aviation industry consists of airports, aircraft, and related facilities, such as taxi and flight food services. Airports act as interfaces, connecting landside and airside operations. In recent times, airports have evolved into transport and infrastructure hubs supporting commercial, industrial, and business activities. This expansion has led to the development of airport metropolises, with surrounding areas transforming into cities. Consequently, ecological impact during airport construction and operation is expected to increase.



**Figure6:** *Schematic of the interior space of an airport in a region with a dry climate, which is powered by solar cells (on sunny days) and wind energy (on cloudy days).*

Airports require vast and flat land areas, often acquired through reclamations from marshy and agricultural lands, which disrupts the ecological balance. These lands are used for constructing large air-conditioned buildings, runways, and sound buffer zones. The energy consumption of a large airport is comparable to that of a city with 100,000 residents. Energy analysis of the 14 largest airports in Greece revealed an average heating energy requirement of approximately 68 kWh/m<sup>2</sup> and an average energy usage for lighting and motion of 172

kWh/m<sup>2</sup>, resulting in a total energy consumption of around 240 kWh/m<sup>2</sup>.

Cochin Airport, for example, has a daily electrical energy requirement of approximately 50,000 units, leading to substantial energy bills. Currently, airports, including Cochin Airport, rely heavily on electricity generated from conventional sources like coal, natural gas, and hydro power, resulting in environmental pollution from the airport's construction phase onward.

To address these issues, it is imperative to transform airports into sustainable and

environmentally friendly facilities. Various methodologies and assessment frameworks have been proposed to guide the future

development of airports and terminal buildings, focusing on sustainability indicators, their quantification, evaluation, and weighting.



**Figure7:** Schematic of the exterior space of an airport in a region with a dry climate, which is powered by solar cells (on sunny days) and wind energy (on cloudy days).

Researchers have developed an effective framework for ranking different renewable energy systems in airports. Multiple studies have analyzed the services, quality, energy consumption, carbon dioxide emissions, and environmental impact of airports. It has been found that consuming energy from renewable sources can greatly reduce the ecological impact of airports. Specific solutions, such as load management and smart systems, have been proposed for optimizing energy consumption. Solar and cogeneration energy have been identified as the most potential benefits for airports. Wind energy is suitable for some airports, but caution must be taken due to potential interference with radio navigation systems. Other renewable energy sources like biomass and geothermal are site-dependent and may not be suitable for all airports. An optimization model has been developed to determine the optimum share of renewable energy sources in different areas of airports,

such as heating and cooling. Solar PV systems are particularly favorable for airports due to vast land plots and large buildings with spacious roof areas. They can help reduce urban heat island effects and synchronize with HVAC loads. Solar PV systems also have low GHG emissions, require less maintenance, and have long lifespans. The performance of solar PV systems in airports has been evaluated in various locations, and the results have been compared with predicted values from simulation software. Research on the performance of solar-powered airports is scarce, but studies have shown that solar energy is a suitable renewable source for meeting the energy needs of airports. This study aims to analyze the performance and benefits of a 12 MWp solar power plant installed at Cochin Airport, based on actual monitored data. The objective is to provide insight into the environmental and economic benefits of solar-powered airports.



**Figure8:** Schematic of the interior space of an airport in a region with a dry climate, which is powered by solar cells (on sunny days) and wind energy (on cloudy days).

## Conclusion

The airport's commitment to a future powered by renewable energy sets a remarkable example for the aviation industry. By integrating wind energy on cloudy days and exploiting solar energy on sunny days, this modern Middle Eastern airport showcases that sustainability and economic success can go hand in hand. The

adoption of renewable energy sources not only reduces carbon emissions but also enhances the airport's resilience, reputation, and operational efficiency. In embracing this sustainable revolution, the airport demonstrates its dedication to establishing green skies and leading the way towards a greener future in aviation.

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