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Evaluation of sustainable Performance of Airport buildings in Egypt

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Abstract: The construction industry has a vital impact on the environment and people. On a global scale, the construction industry and its products contribute to environmental problems through the resources that consume energy, air pollution and waste generation. Airport buildings are also important buildings in which sustainable technology is used to increase their operational efficiency, as they are characterized by the presence of elements of construction, mechanical, communications and information technology. The study addresses a number of international airports in Egypt and includes the role of sustainable technologies and their impact on the building and the service system in the building, where sustainable design ideas and the technology used are studied and results are drawn, and the extent of response to the role of sustainable technologies in raising the efficiency of the project is monitored, and then the impact and results of these studies on the project are known and the strengths and weaknesses are known to try to apply sustainable technological trends to other airport buildings and reach recommendations so that they are sustainable airports that raise their operational efficiency in the future.

I. INTRODUCTION

Egypt plays an important role in the aviation sector as it is a transportation and trade canter in the Middle East and North Africa region. Egypt has recently achieved rapid growth in the civil aviation sector thanks to economic growth and population growth. Egyptian airports are witnessing a major development movement to keep pace with the Egyptian state's sustainable development plan 2030. This plan includes the construction of new buildings in some airports and focuses on the human element and provides it with the appropriate atmosphere to perform its work efficiently and easily. The study addresses several international airports in Egypt and includes the role of sustainable technologies and their impact on the building and the service system in the building. The extent of the response to the role of sustainable technologies in raising the efficiency of the project and its impact on it is monitored.

Keywords:

Sustainable Performance -Eco-Tech -Airport - Cairo International Airport- Borg El Arab Airport.

2.OBJECTIVE

The applied study aims to study some important Egyptian models and apply the proposed model to the research samples to measure and evaluate the experience of sustainable airports (ECO-Airport) in Egypt and to know the strengths and weaknesses to reach recommendations to apply them to Egyptian airports so that they are sustainable airports that raise their operational efficiency in the future.

3.APPLIED STUDY METHODOLOGY

The architectural models that were created at the beginning of the twenty-first century are studied, due to the impact of sustainable technology on the architectural product that period witnessed.

The selection of the airport model represents one of the energy-consuming projects, which requires the presence of technologies of finishing materials and coverings for large areas and large seas that require a special type of structural thinking of design and implementation. Airport buildings are also important buildings in which sustainable technology is used to increase their operating efficiency, as they are characterized by the presence of elements of structural, mechanical, communications and information technology and are considered suitable for study in this field.

The sustainable design ideas and technology used are studied and the current status of Egyptian airports is evaluated in light of the environmental strategies applied in international airports, and then the impact and results of these studies on the project are known.

Borg El Arab Airport is the first environmentally friendly passenger terminal currently being built in Egypt, (Ministry of Civil Aviation, 2022).Therefore, it will be taken as an analytical model for the sustainable study as the first sustainable and environmentally friendly Egyptian airport, in addition to Cairo Airport, which is classified as the airport with the highest percentage of passenger traffic, with international flights at 81%, compared to domestic flights at 19% in 2008, and the highest air traffic for the year 2019-

2020, and therefore it was chosen to be the study sample model.(Ministry of Civil Aviation - Egyptian Holding Company for Airports and Air Navigation, EHCAAN).

4.STRUCTURE OF ANALYTICAL STUDY:

The study samples are evaluated individually through the following points:

4.1 General study of the airport:

A- Airport location.
B- Objective of establishing the airport.
C- Project elements.

4.2 Study the use of sustainable technologies and solutions through:

A- Design concepts in the building.
B- Eco-tech techniques used in the building.
C- Building sustainability strategy.
D- Analysis of the relationships between the three dimensions of sustainable development (environmental, economic, social).
E- Environmental techniques used to raise the efficiency of the airport.

5. ANALYTICAL STUDY:

The comparative approach was followed to study the environmental trends used in each of the airports in the study sample, which works to increase the sustainability of the building.

Several methods were used to collect data through repeated and direct interviews with engineers and officials, applying the derived model, reviewing records and reports whenever possible, and field visits to the implementation sites whenever possible.

The proposed model was applied to project managers and implementation managers whenever possible, in addition to site engineers, supervision engineers, and project consultants, through different administrative levels with a sample size of 5-10% as a minimum statistically permissible due to the difficulty of obtaining information freely and due to security reasons.

The statistical analytical approach was adopted using the Intelligent Guess investigation, which is a detailed scale measured by percentages (0% not achieved, 25% weak, 50% average, 75% good, 100% excellent), for the purpose of reaching the study results and reaching the study goal system.

This framework is presented to project engineers, supervisory engineers, project consultants and project managers whenever possible to set percentages for the extent to which the building sustainability strategy has been achieved, and from there to reach the percentage of building sustainability achievement, and from there to deduce the percentages achieved in the two local study samples.

The sum of the percentages for each item within the study represents the percentage of application of the items within each process, and then calculating the extent to which each study has achieved the building sustainability strategy, and from there each item of project sustainability has a percentage through which the percentage of application of the building sustainability strategy can be measured.

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The structure of the analytical study is based on evaluating the current performance of the environmental airport in Egypt through:

• Determining the level of sustainable performance for each airport based on the selected indicators.
• Comparing different airports and identifying the difference in sustainable performance.

6.AIRPORTS AND SUSTAINABLE DEVELOPMENT:

Interest in the concept of achieving sustainable development began in the early seventies of the twentieth century when it was noted that there was a significant shortage of non-renewable natural resources.

The beginning of research was through the Massachusetts Institute of Technology (TIM). In 1980, the International Union for Conservation of Nature developed the first global conservation strategy. In 1983, the United Nations formed a global committee for environment and development tasked with studying environmental and development problems on planet Earth. At the first Earth Conference held in Rio de Janeiro in 1992, the focus was on the future of future generations and their right to obtain energy that suits their needs in the future, (Hamed Hatal, 2007).

In conjunction with the growing awareness of environmental problems, many architectural trends have emerged that adopt and support the idea of the importance of environmental balance, such as the green architecture trend. “The term ‘green building’ refers to a building that is designed, constructed and managed in a sustainable and efficient manner, and is subject to some international standards granted by specialized institutions to measure the extent of the building’s compatibility with the environment and the possibility of classifying it as a green building.

The US Environmental Protection Agency (EPA) defines green or sustainable architecture as a set of buildings that use environmentally compatible technology, and include the idea of preserving available resources, starting from the design,

construction and implementation of the building, all the way to the operation, maintenance and even restoration of the building, taking into account providing health and comfort factors for the building users,(U.S. Environmental Protection Agency).
The British Standards Institution is also formally committed to achieving the Sustainable Development Goals (SDGs), (The British Standards Institution,2024).

6.1 LEED (LEADERSHIP IN ENERGY AND ENVIRONMENTAL DESIGN):
LEED is a green building rating system used to evaluate and classify the sustainability of buildings, including energy, water, building materials, indoor environmental quality, and innovation in design. Airports can also obtain LEED certificates for their new or renovated buildings to improve their sustainability performance with specific conditions and standards that must be met to obtain the certificate. As follows, (U.S. Green Building Council, 2024)

1- **Strategic locations**: These conditions include choosing a location that contributes to reducing reliance on personal cars, increasing access to public transportation, and reducing negative environmental impacts.
2- **Water**: The building must achieve water efficiency by using water-saving devices and effective water management techniques.
3- **Energy**: LEED requires buildings to achieve high energy efficiency by using natural lighting techniques, efficient heating and cooling systems, and highly efficient electrical appliances.
4- **Materials and resources**: The materials used in construction must be sustainable and recyclable, and construction waste must be reduced.
5- **Indoor Environmental Quality**: This aspect includes achieving comfortable indoor air quality for residents and visitors using environmentally friendly materials and effective ventilation techniques.
6- **Innovation**: LEED encourages excellence in design and innovation in the areas of sustainability, including the use of new technologies and innovative practices.
7- **Regional Priorities**: LEED verifies that building designs support regional sustainability priorities, contributing to a greater positive impact on the local community.
8- **Operation and Maintenance**: LEED requires buildings to be designed and certified to contribute to maintaining high environmental, economic and social performance over the long term.

6.2 BREEAM (BUILDING RESEARCH ESTABLISHMENT ENVIRONMENTAL ASSESSMENT METHOD):
BREEAM, (according to the page of BREEAM visited on 18.8.2024) is an environmental rating system used to evaluate the sustainability of buildings worldwide, focusing on several key areas to achieve building sustainability. It evaluates the performance of buildings in areas such as energy, water, materials, health, well-being and management.
Airports can also use BREEAM to evaluate and improve their sustainable performance and obtain certificates that demonstrate the level of sustainability achieved.

The conditions that must be met to obtain a BREEAM certificate at one of its approved levels are as follows:

- **Project management and performance**: The building must have a clear strategy for managing the project and ensuring sustainable performance throughout the building's life.
- **Health and well-being**: This aspect includes ensuring the provision of a healthy and comfortable indoor environment for users, including indoor air quality, natural lighting, and temperature and humidity control.
- **Energy**: High energy efficiency must be achieved in the building by designing integrated buildings in a way that achieves the minimum level of energy consumption and emissions.
- **Water**: BREEAM requires the use of water efficiency through pipe designs, water-saving devices and water management systems.
- **Materials:** The building should use sustainable and environmentally friendly building materials with a focus on minimizing construction waste and achieving a sustainable life cycle for materials.
- **Pollution**: This aspect includes reducing the harmful environmental impacts of the building on its surrounding areas through reducing emissions of hazardous chemicals and managing waste.
- **Innovation:** Innovation is encouraged in the design and operation of buildings to achieve better performance in sustainability areas, such as the application of new technologies and innovative practices.
- **Installations and Technology**: The installations and technology used in the building should be integrated and enhance the efficiency of the use of resources and energy.
- **Communication and Instruction**: This aspect includes ensuring that residents and users of the building are aware of sustainable practices and instructions to make the most of sustainable designs.

These are some of the programs and standards that can help airports assess and improve the sustainability performance of their buildings.
Airports can choose the most appropriate program or standard based on their specific needs and applicable local and international laws.

7. AIRPORT SUSTAINABILITY STRATEGY :

Traditional airports have been transformed into green airports,(Dimitrios Dimitriou; Aristi Karagkouni,2022), as Norman Foster at Stansted Airport switched mechanical services to the basement to create an opportunity for ground-level cooling, while air conditioning was placed in the ceiling and this was reflected in the natural light that penetrated the building and daylight and the structure were exploited to achieve a station with an environmental architectural character, (Malcolm Quantrill, 1999).

Foster identified three problems with the roof services: firstly, the weight of the roof and the structural frame; secondly, the disruption of passenger movement due to the opaque solid roof; and thirdly, the dark environment of unknown origin due to the suspended roof. Foster turned the previous assumptions into energy saving results, and despite the small size of Stansted Airport, it represents the beginning of a new generation of airport terminals where energy is saved by using daylight instead of artificial light.

Reducing artificial lighting reduced cooling and ventilation levels and introducing daylight from structural supports created an opportunity for passengers to orient themselves through the architecture of light and columns.

The proposed model and sub-processes for integrating the building sustainability strategy derived from the BREEAM and LEED rating system for evaluating the sustainability of buildings, (U.S. Green Building Council, www.breeam.com) as follows:

Table 6.1: Building Sustainability Strategy

Building Sustainability Strategy	
Strategic locations	The site contributes to reducing reliance on personal cars. Increase access to public transportation, reduce negative
Water	Use of water-saving devices Use of effective water management techniques
energy	Use natural lighting techniques Use efficient heating and cooling systems Use highly efficient electrical appliances. Design integrated buildings to achieve minimum energy consumption and emissions.
Materials and resources	Use sustainable and environmentally friendly building materials Recyclable building materials Reduce construction waste Achieve a sustainable life cycle for materials.
Indoor environmental quality	Achieve comfortable indoor air quality for users Provide a comfortable environment using natural lighting Control temperature and humidity. Use environmentally friendly materials Use effective ventilation techniques.
pollution	Minimize the harmful environmental impacts of the building on the surrounding areas Reduce emissions of hazardous chemicals Waste management.
Innovation in technology and formulations	Encourage innovation in the design and operation of buildings in the areas of sustainability Use of new technologies and innovative practices that enhance the efficiency of resource and energy use.
Operation and maintenance	Buildings are designed and certified to contribute to maintaining high environmental performance Maintain economic performance Maintain social performance in the long term.
Project management and performance	There is a clear strategy for project management Achieve sustainable performance throughout the life of the building.
Communication and instructions	This aspect includes ensuring that residents and users of the building are familiar with sustainability practices and instructions to maximize the benefits of sustainable designs.

8. MAIN SUSTAINABILITY MEASURES

Sustainable development deals with the environment through three basic dimensions: (environmental-social-economic dimension) with the aim of achieving a set of goals that meet the requirements of society and harmonize with the environment in a way that achieves maximum benefit from natural capabilities in addition to reducing the cost of materials by recycling them in a healthy way (Sam C M Hui,2002), Sustainable performance indicators were also identified that symbolize the economic, environmental, and social dimensions and measures of airports, (Litman, T, 2011), and include:

Table 7.1 Key aspects of sustainable performance at airports (Key Sustainability Metrics), (Sam C M Hui,2015).

Key Aspects of Sustainable Performance at Airports	Sub-indicators and details
First: Environmental standards and dimensions	
Carbon footprint	Measurement of carbon dioxide (CO2) emissions from airport operations, including air transport and ground facilities.
Energy consumption	Renewable energy sources
Water use	Energy efficiency.
Protection of biodiversity and natural resources	Proportion of renewable energy used in airport operation compared to total energy used.
Waste management	Wastewater management
Air quality	Water efficiency
Second: Social standards and dimensions	
Local community impact	Collaboration with local communities Training and development programs Social, cultural and educational initiatives
Working conditions and safety	Accident rates Occupational health and safety policies. Safety of passengers and employees
Enhancing transparency and partnerships	Integrity in relations with companies Transparency in management and decision-making.
Internal work quality	Employee welfare and working conditions
Third: Economic measures and dimensions	
Cost and revenue efficiency	Reduce overhead costs Cost-benefit analysis of sustainability initiatives Increase revenue from sustainable sources.
Innovation and investment in technology	Application of clean technology Innovation in airport management and services.
Economic impact on the local community	Job creation support local businesses Positive economic impact. Efficient use of financial resources.

9. THE ROLE OF TECHNOLOGY AS AN EXPRESSIVE AND ENVIRONMENTAL TOOL IN AIRPORT BUILDINGS:

Airport terminals are a center where contemporary technological capabilities meet, reflected by designers' ideas in expressive language, its tools are the capabilities of the structural framework that produced a generation of tectonic airport buildings in which the shape of the buildings responds to the surrounding physical forces and interacts with them in internal spaces and in which light interacts with the structural framework in a purposeful rhythmic language.

The structural framework of modern airport buildings plays a major role, whether in its elements, structural details, or structural form, and with different symbolic and expressive environmental functional capabilities. Airport terminals reflect construction technology more than any type of specialized buildings, as airport technology is considered a reflection of the advanced and continuous technology of airports, (Frampton, K,1995).

10.ECO-TECH TECHNIQUES USED:

The use of environmental technology techniques adapts the building to the external environment and makes the internal environment adapt to the external environment through the building envelope. This is done by designing the building in an integrated manner between the design process, systems and activities in a way that makes the building high-performance, energy-intensive and sensitive to the environment and climate, (Bachman, 2003, p145).

Airports represent one of the most important types of smart buildings. (David Boyd, 1987) believes that the term smart building refers to those buildings that contain high levels of advanced industrial technology that are also able to adapt to their internal environment in response to external conditions and forces, (Edwards, 2005, p266; Ashford, 1991, p292)

10.1 ARTIFICIAL LIGHTING:

Lighting is a tangible element in the design of the interior spaces of passenger terminals in general, and artificial lighting at the airport represents the main source of energy consumption.

The main source of energy consumption is artificial lighting, exceeding the energy consumed for cooling and heating, and a small number of airport terminal buildings depend on artificial lighting completely, and the need to use a pattern of organized lighting patterns during the night and day so that passengers' perception of movement directions and spaces does not differ.

10.2 NATURAL LIGHTING

Directing contemporary airports to obtain large amounts of natural lighting is one of the means of conserving energy and reducing the level of heat generated from industrial sources.

Most modern airport terminals are designed as solar buildings, as transparency helps conserve energy, but excessive glazing leads to the loss of thermal capacity through the building fabric, as airports with glazed spaces, despite reducing energy consumption and artificial lighting, lead to partial or complete air conditioning, (Edwards, 2005, p266).

Balancing energy use between natural and artificial lighting is a difficult process that depends on local conditions, because heat loss through windows must be compensated for by the release of energy emitted from other sources that may be fuel-based.

10.3 UTILIZING SOLAR ENERGY:

The size of the airport is suitable for using solar energy, as solar energy can be used to generate warm water needed by restaurants or airport hotels, to generate electricity or produce heat or cold. In areas with high solar density, concentrated solar heat can also be used to produce steam for steam turbines that operate, (Matthias Pöter, Sector Director Airports, deerns company, Netherlands, 2024).

10.4 NATURAL VENTILATION:

Most airport stations depend on artificial air conditioning throughout the year or part of it, whether for the entire building or part of it, and the systems work to circulate air as a means of cooling or heating, and the shape of the space represents the most important element in the degree of penetration of the rushing air and the way it moves, and the air conditioning system determines the shape of the roof of modern airport buildings and the shape of the side section of the building helps in circulating air as in the wavy and curved roofs forming the side of the Kansai Airport building, the Oslo Airport building in Norway and the Charles de Colle Airport building in Paris, all of which come as a direct response to the air distribution process, (Edwards,2005, p167).

10.5 ENERGY CONSERVATION SYSTEM:

One of the basic principles of sustainable architecture and sustainable architectural design is the principle of energy conservation: The decision to conserve energy includes determining the specific climate conditions for the direction of the building, the thickness of the walls, and the conscious planning of the site and energy by taking advantage of its shape. The ice storage system helps cool the building by pumping ice, or cooling the building directly, or cooling it directly during the day by chillers.

The airport near the sea can also be cooled by cooling energy from the sea, Matthias Pöter, Sector Director Airports, deerns company, Netherlands, 2024), using cold water from deep water, even in tropical areas.

10.6 WASTE, BIO-WASTE AND CO-GENERATION:

Large numbers of people produce large quantities of wastewater. The bio-waste that remains after biodegradation can be fermented and converted into biogas to be used as fuel for a thermal power plant that generates electricity, heat and cold, Matthias Pöter, Sector Director Airports, deerns company, Netherlands, 2024).

11. ENVIRONMENTAL TECHNOLOGIES USED TO INCREASE THE EFFICIENCY OF AIRPORTS:

With the huge increase in air traffic and the number of people involved in their operation, airports are increasingly facing the negative impacts they have on the environment, and this has created the need for airports to operate with minimal environmental load.

It is possible to organize the airport so that the basic functions perform well and are organized in an energy-saving manner so that it is a green airport that reduces energy consumption by, (FEDERAL STATISTICAL OFFICE, 2019):

Table 11.1: Environmental technologies used to improve airport efficiency

Environmental technologies used to improve airport efficiency	
Reducing energy demand	Relying on reducing consumption of all aspects of energy (electricity - air conditioning - water - ..... etc.)
sustainable energy	Thinking about using sunlight Using renewable solar energy Benefiting from sustainable natural sources of cold and rainwater Installing active elements to generate and store energy additionally
Use the conversion efficiency of external power supplies	Benefiting from naturally available waste products when generating energy, such as using biogas generators A fuel supply system to save energy as the building contains a fuel station that reduces the volume of carbon dioxide Not using large vehicles for fuel supply

	A closed cycle for energy with the highest efficiency of fossil fuels, (reducing consumption) Waste management The presence of equipment and/or systems to control and treat waste within the airport
Passive design strategies to reduce carbon footprint	Using natural light Using passive design to reduce energy consumption Ventilation to improve productivity Technological methods for construction Saving energy costs over the life of the project Reducing Relying on mechanical systems Using climate principles to regulate temperature Using green buildings on facades or above the roof of the building to enhance thermal insulation efficiency Orientation and positioning of the building in relation to the sun and wind Reducing heating and cooling systems Suitable indoor climate Not using mechanical ventilation systems Choosing openings to allow air to enter Improving the thermal envelope of the mini Using materials that could exchange heat so that they absorb the sun during the day and release it at night.

12. PRACTICAL STUDY:

12.1 BURJ AL ARAB INTERNATIONAL AIRPORT PHASE2:

The project of the first environmentally friendly passenger terminal at Borg El Arab Airport, in cooperation with the Japanese International Cooperation Agency (JICA), is one of the most important civil aviation projects within the framework of the transformation to environmentally friendly airports, through the use of solar and renewable energy, rationalization of energy consumption and reduction of pollution, in line with the strategic objectives of Egypt's Vision 2030, which aims to achieve the state's plan to stimulate incoming tourism to Egypt, increase passenger traffic and travel and development rates in various governorates, and will be run on solar energy, which will provide a 20% fuel reserve that can be sold and benefited from its price. The environmentally friendly airport is also distinguished by recycling its waste, rationalizing lighting, reducing emissions and recycling water, (Burj Al Arab Airport project Manager,2023).



Figure12.1. Perspective shot of Borg El Arab Airport design - Terminal 2, (Egyptian Airports Company, 2022).

12.1.1 GENERAL STUDY OF THE AIRPORT:

A. Airport location:

Borg El Arab Airport 2 is an international airport located in Alexandria. Its area is 36 thousand square meters, so the total capacity of the airport reaches 6 million passengers annually.



Figure12.2. Burj Al Arab Airport Location, (www.google.com)

B. OBJECTIVE OF ESTABLISHING THE AIRPORT:

JICA (Japan International Cooperation Agency,2022) is interested in developing airports as one of the pillars of Egypt's infrastructure in order to achieve foreign currency revenues. The project plan includes designing Borg El Arab International Airport to be an "environmentally friendly airport" in response to the global demand to reduce the effects of climate change and reduce the environmental burden, as advanced Japanese technology will be used to operate the airport with solar energy, a highly efficient air conditioning and lighting system, and other technologies within the concept of this type of environmentally friendly airports. (Ministry of Civil Aviation, Egypt))

To achieve this goal, JICA provided related facilities and equipment such as solar power generation cells, high-efficiency air conditioners, energy-saving LED lighting devices, and photocatalytic stimulation to achieve the concept of environmentally friendly airports.

C. PROJECT ELEMENTS:

The building consists of two floors in addition to 40 counters to complete travel procedures, and 16 counters for passports, technical and technological systems that will be installed in the building according to the latest technologies available in the field of airports globally, the establishment of a new "tarmac" that can accommodate 20 medium-sized aircraft, with a total area of 100 thousand m2, and roads connecting the current and new tarmac, and the current runway, the establishment of a parking lot that can accommodate 1000 cars, a service area and shops to serve travelers and a sewage station and a substation and a water tank and the establishment of a new air taxi with all its equipment, and linking it to the old airfield and the establishment of service roads and raising the efficiency of ensuring the safety of landing and take-off of aircraft in accordance with international standards to ensure the safety and security of civil aviation, and raising the efficiency of operations at the airport, (Japan International cooperation Agency,2022)

12.1.2 STUDY THE USE OF SUSTAINABLE TECHNOLOGIES AND SOLUTIONS:

12.1.2.1 ENVIRONMENTAL DESIGN CONCEPTS IN THE BUILDING:

Technology did not play a role as an expressive and environmental tool in airport buildings, so the building design was limited to the traditional flat-roof design without any new environmental design ideas for the building.

There is flexibility in the orientation of spaces with clarity of movement, in addition to the availability of the concept of wide seas in waiting, arrival and departure halls, and providing larger spaces for the use of natural lighting. In addition to the lack of open spaces to direct movement, and reliance on signboards.

12.1.2.2 ECO-TECH TECHNOLOGIES USED IN THE BUILDING:

There are well-thought-out strategies to save energy and reduce carbon dioxide emissions, including the use of a solar energy system and a VRV air conditioning system, which saves energy and reduces thermal emissions. Larger spaces are also provided for the use of natural lighting in addition to LED industrial lighting, which saves energy consumption, as will be mentioned below:

1-PHOTOVOLTAIC POWER SUPPLY SYSTEM:

Borg El Arab Airport has Introduction of Technology for Environmental Measures, which is represented in the use of solar energy, where the generated energy is: 1.4MKVA, with a reduction rate of carbon dioxide/year: 1,346 tons.



Figure12.3: Using Solar Energy System at Borg El Arab Airport - Terminal 2
(Egyptian Airports Company, 2023)

2 -USING VRV SYSTEM IN HEATING, VENTILATION AND AIR CONDITIONING (HVAC):

VRV system is used in heating, ventilation and air conditioning (HVAC) systems in Terminal 2,(General Manager of Planning and Project Manager of Burj Al Arab Airport 2,2023), it is a system that uses high-efficiency equipment with variable flow rate to control the refrigerant gas, and allows individual control in the room., Partial load operation possibility, use of refrigerant gas only, advanced energy-saving control system.

VRV system is applied in Terminal 2 in individual spaces such as offices, waiting areas and privilege lounges and is used in large spaces using air handling units AHU such as the departure hall, check-in hall, entrance hall, arrival hall, passport control counters.

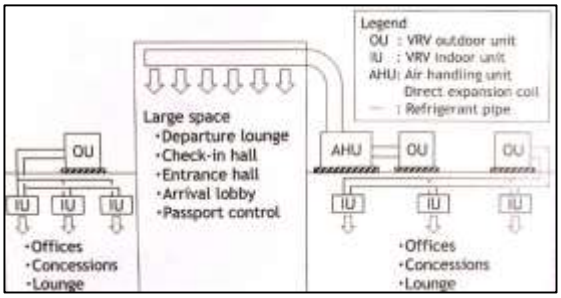


Figure12.4: VRV system used in air conditioning system, (Egyptian Airports Company, 2023)

3-USING RECYCLED WATER:

Burj Al Arab Airport includes a sewage station and a water tank, where the irrigation network treats and recycles water using a treatment system with a capacity of 1,380 tons/day.

The water supply is using recycled water in irrigation network for planting from wastewater, where the sewage network in the building goes to the treatment tanks and the sewage water is treated to be suitable for agriculture and from there it goes to the irrigation network tanks, and the capacity of the irrigation tank is 1,070 tons and the volume used is 300 tons/day

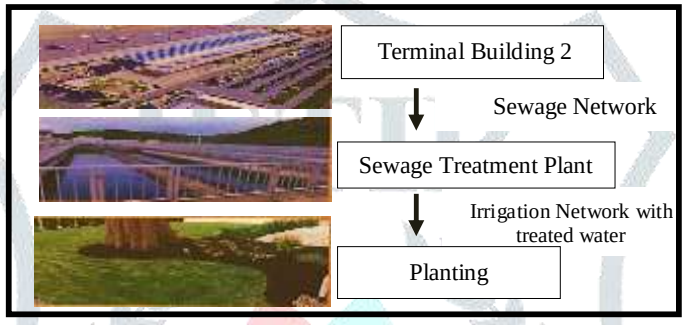


Figure12.5: Water supply using recycled water from sewage – Borg El Arab Airport Terminal-2, (Egyptian Airports Company, 2023)

4-BUILDING MANAGEMENT SYSTEM:

The Building Management System (BMS) efficiently manages energy by monitoring in conjunction with systems that support energy management. The BMS provides real-time monitoring and reporting of various airport systems from heating, ventilation, air conditioning, lighting and security from an economic and environmental perspective.

It is flexible and provides a full service for architectural spaces that allows scalability from small and medium to large and complex systems. It also improves operation in order to reduce energy consumption and reduce stress on system components.

Create schedules for automatic operation of electrical systems based on occupancy schedules. It is noted that there is a single-entry point for users to operate, monitor and improve the building's automated control systems and the security and fire safety system.



Figuer12.5: Building Management System, (Egyptian Airports Company, 2023)

5-INSTILLATION OF FUEL HYDRANT SYSTEM:

There are well-thought-out strategies to save energy at Burj Al Arab Airport 2 and reduce carbon dioxide emissions from it, as the building contains a fuel station that works to reduce the volume of carbon dioxide without using large vehicles for fueling.

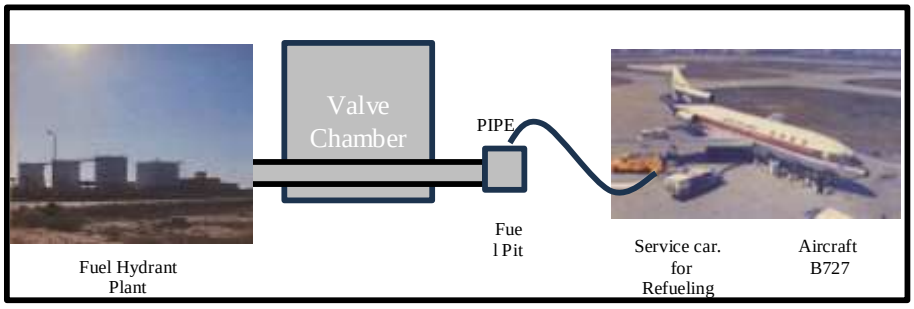


Figure12.6: Fuel Hydrant System, (Egyptian Airports Company, 2023)

6-SUSTAINABLE TECHNOLOGIES USED IN THE BUILDING'S ELECTRICAL SYSTEM:

The building's lighting system includes some environmental measurement technology, as the building includes energy-saving lighting equipment using LED technology, a human sensor for switching on off in the lighting of toilets, and a Shading Glass system with a certain light transmittance, (Egyptian Airports Company, 2023)

7-TECHNOLOGIES USED TO REDUCE POLLUTION:

The project of the first environmentally friendly passenger terminal at Borg El Arab Airport is considered one of the most important civil aviation projects within the framework of the transformation to environmentally friendly airports by exploiting solar and renewable energy, rationalizing energy consumption and reducing pollution.

The building relies on reducing carbon emissions and generating electricity using a solar energy system, reducing thermal emissions using the VRV air conditioning system, and providing larger spaces for the use of natural lighting in addition to LED industrial lighting that saves energy consumption in order to keep pace with the developments witnessed by the world in relying on solar energy.

Reducing the harmful environmental impacts of the building on the surrounding areas, as well as reducing emissions of hazardous chemicals and reducing carbon dioxide emissions.

The building does not adopt the idea of waste management, and there is no equipment and/or systems to control and treat waste within the airport, and noise and air pollutant measurement devices will be supplied soon.

8 -INDOOR ENVIRONMENTAL QUALITY (HEALTH AND WELL-BEING):

Health and well-being indicators are achieved by achieving comfortable indoor air quality for users, and providing a comfortable environment using natural lighting, as larger spaces are provided for using natural lighting with temperature and humidity control and using effective ventilation techniques. As explained in the section on ventilation and air conditioning.

9-MATERIALS AND RESOURCES:

The use of environmentally friendly materials is low, as all materials used are imported, as the project uses imported technology and there are no local environmental materials or sustainable building materials. Also, building materials are not recyclable and construction waste cannot be reduced, but there are ideas to achieve a sustainable life cycle for materials in the near future.

Other systems and equipment to be introduced at the airport include:

- Electric buses and vehicles (Follow-Me, etc.) and GSE vehicles such as forklift, Toeing tractor and cargo truck inside the airport
- Electric buses will be established to transport passengers from the airport to the station near Alexandria in the near future
- Electrical Ground Power Unit Electrical Ground Power Unit
- Equipment for controlling emissions for generators
- Equipment and/or systems for controlling and treating waste inside the airport.

10-OBTAINING A CERTIFICATE OR CLASSIFICATION SYSTEM FOR THE AIRPORT'S ENVIRONMENTAL DESIGN:

Borg El Arab Airport Terminal 2 is the first environmentally friendly passenger terminal currently being built in Egypt, and the first environmentally friendly airport in Africa, as it is the first environmentally friendly passenger terminal project at Borg El Arab Airport in cooperation with the Japanese Agency "JICA" because it includes a set of environmental measurement technologies as previously explained.

The building is considered one of the most important civil aviation projects within the framework of the transformation to environmentally friendly airports; In response to the global demand to reduce the effects of climate change and reduce the environmental burden, advanced Japanese technology was used to operate the airport with solar and renewable energy, rationalize energy consumption and reduce pollution, and use a highly efficient air conditioning system, energy-saving LED lighting devices, photocatalysts, and other technologies, in line with the strategic objectives of Egypt's Vision 2030, and to achieve the concept of environmentally friendly airports, (Egyptian Airports Company, 2023). But it does not have any environmental design classification or certifications.

13.2 CAIRO AIRPORT - TERMINAL 3:

Egypt witnessed a transformation in the world of civil aviation with the establishment of Terminal 3 at Cairo International Airport,(Ministry of Civil Aviation, EHCAAN, Egypt)and became able to compete according to the level of the international code for advanced airports due to its integrated technological system for operating devices, in addition to the good design that makes the passenger feel as if he is in a European country.



Figure13.7: External view of Terminal 3, (google.earth.com)

13.2.1 GENERAL STUDY OF THE AIRPORT

A. Airport location:

Cairo Airport is in Cairo Governorate, 22 km southeast of the city center, and the project is located next to Terminal 2 to benefit from the services provided by this building



Figure13.8: General layout of Cairo Airport Building 3

B. THE PURPOSE OF ESTABLISHING THE AIRPORT:

Cairo Airport 3 is classified as an international-transit airport, located on an area of 190 thousand m2, which is equivalent to twice the area of buildings 1, 2.

Studies were conducted in the nineties of the last century that confirmed the importance of the need to increase the capacity of Cairo International Airport as a result of the expected increase in passenger traffic in 2020 to about 20 million passengers annually, and that the maximum capacity of Terminals 1 and 2 is 6-9 million passengers annually, so the Ministry of Civil Aviation, represented by the Holding Company for Airports and Air Navigation and Cairo Airport Company, established a new Terminal 3 with a capacity of 11 million passengers per year, which is more than the capacity of Terminals 1, 2.

C. PROJECT ELEMENTS:

The building consists of the following:

- basement containing the building's services, including rooms for electromechanical equipment, maintenance workshops, warehouses, and changing rooms for employees.
- Three main floors: The first floor was allocated for arriving passengers, the second floor for departing passengers on international flights, and the third floor was allocated for travel and arrival from domestic airlines.
- Two mezzanine floors: It includes administrative offices, airline offices, and the services necessary to serve and monitor air traffic.
- The building includes five commercial areas with an area of 3300 m2, a restaurant and cafeteria area with an area of 9000 m2, a business service canter, and two areas for receiving important visitors and senior delegations, which achieves the highest rates of the global code in services, facilities, and insurance to achieve maximum passenger satisfaction.
- The building is equipped with 110 counters for travel and completing procedures, and a passport area that contains 38 counters, including 2 self-service counters with eye and fingerprints, in addition to international restaurants with an area of 2175 m2 and a duty-free area with an area of 3935 m2. Terminal 3 also accommodates 15 aircraft at a time and 40 aircraft parking spaces that are transferred between them by buses equipped to receive any type of aircraft, in addition to 1500 parking spaces for cars, 250 parking spaces for buses and taxis, and 375 parking spaces for employees.

13.2.2 STUDY THE USE OF ENVIRONMENTAL TECHNOLOGIES AND SUSTAINABLE SOLUTIONS, (Head of Architectural Department, ECG Company, 2013).

13.2.2 .1 ENVIRONMENTAL DESIGN CONCEPTS IN THE BUILDING:

Amsterdam Airport is the closest airport to Cairo International Airport3; it was designed by the Dutch company (NACO). The new design concepts of the building are evident through the following:

Flexibility in the direction of closed spaces with clear movement and the availability of the concept of wide seas in the waiting, arrival and departure halls, as the building height reaches 122 m on an area of 164 m2. Lack of open spaces, and reliance on signboards and closed spaces (Holding spaces) to meet security requirements; for the possibility of control and command.

The building includes some design solutions for the spaces, as the problem of Cairo Airport was the difference between the atomic hour for international flights and domestic flights, so the airport design was based on the peak hour. The solutions tended towards making good use of spaces by sharing spaces, so that there would be one shared space for internal and external flights represented by Swing Gates, where the gate opens for internal flights and then closes to open for external flights, and so on. These design solutions were used for the first time in Europe when all flights were internal, and the principle of sharing was also used in belts and bags.

13.2.2 .2 ECO-TECH TECHNOLOGIES USED IN THE BUILDING:

There is no integration between the design process, systems and activities in a way that makes the building high-performance, energy-intensive and sensitive to the environment and climate. The main goal of the airport at that time was to operate the airport and make a profit, without using modern environmental technologies and the building does not provide urban and architectural spaces that flow between the outside and the inside.

The internal environment of the building does not adapt to the external environment through the building envelope, and there is no investment in renewable energy in the design of the building through directing it to the sun, natural ventilation, recycling and using water.

The presence of sensors that have the ability to sense the loads of passengers inside the building, whether increasing or decreasing, to adapt to temperatures, and the building's ceiling maintains the noise level at an acceptable rate of 39-40 decibels, and maintains heat and sound insulation.

Traditional building materials with high load-bearing capacity were used, such as granite for floors, wooden cladding for VIP halls, and aluminum for sun breakers and sections of the main facade and the ceiling of the main hall. Curtain walls were made of marble for the interior halls, glass for the facades and aluminum for the interior halls. Light transparent double insulated glass was used for the main facades - and dark for the side facades due to its low cost. There was a plan to use bullet-resistant glass to be implemented by ICAO, but it was not implemented, while no smart and modern materials were used. - Monitoring results for gaseous concentrations of nitrogen and carbon emissions around the airport showed that the impact of Cairo International Airport on air quality in the surrounding areas and its surroundings is very small. As for peak hours and specific locations around the airport, the concentrations of these emissions approached negative levels, (Main projects of the Holding Company for Airports and Air Navigation, Egypt).

1. SUSTAINABLE TECHNOLOGIES USED IN THE BUILDING'S LIGHTING SYSTEM :

Lighting has no role in organizing internal spaces and directing movement and controlling lighting via a central computer.Relying on closed spaces to control lighting and air conditioning to reduce costs and on natural lighting during the day in a weak manner and artificial lighting at night (halogen lighting), also lighting works were implemented in the third corridor according to the latest international systems that comply with international specifications ICAO and federal specifications FAA, and the latest control systems were used using fiber optics to speed up information transfer with the use of flasher management SFL for the APPROACH area that was installed for the first time in the airports of the Arab Republic of Egypt and was opened in 2010,(Site Supervision Head, at ECG Company during the construction of Terminal 3).

The building includes a completely new power station to supply Building 3 with the necessary operational energy along a length of 55,000 meters.

2- SUSTAINABLE TECHNOLOGIES USED IN HVAC SYSTEM, (Consultant and Head of Air Conditioning Department, Cairo Airport - Terminal 3, ECG Company, 2000):

The air conditioning system in Hall 3 (which has an area of more than 200 thousand m2) represents the latest practical air conditioning systems, with a large cooling capacity that increases in summer, and a heating capacity that increases in winter. - The system was designed and implemented with the highest modern specifications, and is controlled remotely by air dampers and automatic water valves and linked to the hall's automatic main control system, and it has more than 18,000 control points, which helps the system perform at the highest efficiency, which increases the expected life of devices and equipment and reduces the consumption of spare parts and electricity, (Arafa Abu Al-Majd, 2009, P: 41-4).

Cold and hot air is distributed to all areas of the hall through 153 main air handling units with different capacities through a network of sheet metal air ducts that feed approximately 12,000 air outlets, and air is drawn, fed and smoke is drawn by 321 fans with different capacities, there is also a chemical treatment system for cold and hot water.The supply ducts are on the walls, while the return ducts are in the ceilings and one in the walls.

There are sensors in space that could sense the loads of people in terms of increase and decrease and adapt to them to control the temperature through the actual loads of the place, which achieves a small percentage of energy conservation.

The building does not exploit the structural frame to make chimneys to encourage natural ventilation, and the building includes a central air conditioning station.

3- TECHNOLOGIES USED IN THE FIREFIGHTING SYSTEM:

The building includes advanced global alarm and control systems, and 6000 m long Ductile iron pipes are used to fight fires, and there is an automatic fire alarm system in the entire building Alarm System.

The internal space cannot be used to extract smoke and get rid of toxic chemicals because the space is small and the place is cleaned by cleaners, as the structural protection system relies on spray materials to protect against fire, and the larger the section of the structure, the more spraying.

The systems used to combat fires are sprinkler systems through fire-fighting water pipes located in the ceilings and the protection systems for stairs depend on water hoses with the presence of an air pumping system on the stairs and smoke expulsion and air extraction from the building, and the use of foam systems for outdoor areas only, in addition to the presence of a damper to close the air conditioning ducts to prevent air from being pumped during a fire, in addition to the use of CO2 (FM200) gas cylinders in spaces used by passengers, while other inexpensive types are used in unused spaces, such as transformer rooms.

The presence of heat and smoke detectors (an electromechanical system for central control Building Automated System connected to the central control room), through which limited fire areas can be controlled via computer with the presence of a smart fire curtain system with a second fire alarm, in addition to the presence of emergency generators for critical systems for elevators and fire pumps.

The security surveillance cameras system for Cairo International Airport Police, specifically for ambushes and vital areas for the first, second and third phases, has been implemented to raise the efficiency of security systems for all vital areas of the airport, which will have a positive impact on the integrated system for securing the entire airport, ensuring safety and operation, and raising the efficiency of fire stations and equipping them with the latest equipment and fire engines from the largest international companies**.**

4- TECHNOLOGIES USED IN THE COMMUNICATIONS SYSTEM, (Ministry of Civil Aviation, Egypt, 2013):

The latest communications technology was used in Terminal 3 at that time, where a contract was signed with ARINC to implement ITS information, which works to provide the airport with the latest advanced technological means, including the possibility of using eye and finger print technology to complete passenger procedures, in addition to creating an integrated and modern information base to link all operations taking place inside the port from all administrative, financial and technical aspects at a cost of 21 million dollars. Terminal 3 was equipped for the first time in the Middle East with 15 information technology systems, including:

Context aware operational platform system, which helps control the speed of performance and workflow, ensuring the highest efficiency in performance and safety with the latest means of automatic communication between employees.

Personal Profile system, which is used to handle facts and follow up airport workers in the places of travel and arrival of aircraft with a statement of "time - date - system".

Self Service Kiosk system (the principle of self-service for desired services) which allows passengers the opportunity to search for and obtain the necessary information about companies, flights and services available locally and internationally.

Biometric Immigration System which allows exit and entry through airports through the Biometric Specifications System which increases the speed of procedures and reduces the error rate. 5- MUSETM System which covers a special information base for airport operations which supports and improves the level of services provided by companies inside the airport thus completing the system of improving services and facilities.

The building includes two passport counters that operate automatically so that the passenger can complete the travel procedures himself. The self-service kiosks are called CUSS (eye and fingerprint) and there is a smart sound system in addition to IP telephony, which is the latest technology in the field of communications technology, remote communication service, international communication lines, fax and e-mail services, in implementation of the idea and keeping pace with modern technology applications, (Public Relations Department at Cairo International Port, 2013).

5- TECHNOLOGIES USED IN THE WATER CONSERVATION SYSTEM:

The presence of a water station equipped with the latest water purification devices with a capacity of 18,400 cubic meters, and a complete sewage network that contributes to improving the airport's entire sewage system with UPVC concrete pipes, 13,250 meters long, and Apron Drains channels with a length of 6,500 meters, and a complete advanced network for supplying aircraft with fuel with a length of 15,000 meters equipped with the latest global technologies Fuel Hydrant, with a system for isolating grease from kitchens and cafeterias.

There are no systems for preserving, collecting, purifying and storing water in tanks, and using it in cooking, bathrooms, fire extinguishing, irrigation, recycling and using it in flushing boxes and irrigation works.

6- TECHNOLOGIES USED IN THE BUILDING MANAGEMENT SYSTEM (BMS)BUILDING MANAGEMENT SYSTEM:

There are three control rooms inside the building in addition to the BMS- Building Managing System services building. The building is managed using the latest information and communication technology systems to ensure the highest quality in performance and operation of the building.

The presence of green chiller with environmentally friendly, non-colored refrigerant (134A) and the presence of sensors in the holding lounges, which could sense passenger loads, leading to control of lighting, air conditioning and electricity, (Consultant and Head of Mechanical Department, ECG Company, 2013).

14. COMPARATIVE ANALYSIS OF CASE STUDIES:

The following is a presentation of the most important general statistical results extracted from the study samples.

14.1 AREAS OF AIRPORT TERMINAL BUILDINGS:

Cairo Airport is the closest to Borg El Arab Airport in terms of area.

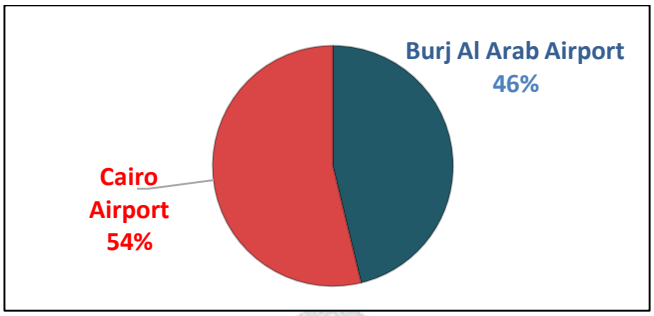


Figure14.1 Airport Terminal Building Areas Practical Examples

14.2 RELATIONSHIPS BETWEEN INDICATORS:

Increasing the use of renewable energy reduces carbon emissions and improves environmental performance. Higher energy consumption can lead to increased carbon emissions, which affects environmental performance.

As for the social aspect, improving working conditions have led to increased productivity and overall employee satisfaction.

Companies' commitment to social responsibility can also enhance the airport's public image and increase positive interaction with the local community**.**

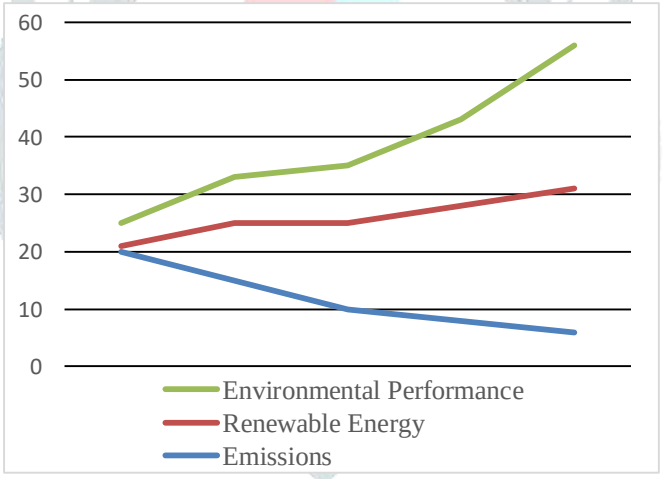


Figure14.2: Relationships between indicators

14.3 ENVIRONMENTAL DESIGN CONCEPTS:

The design of Cairo Airport shows a good presence of concepts. Although the airport design dates back to the late twentieth century, it provides elements of design concepts that affect the space and interior spaces of the building.

The design concepts are low in Burj Al Arab Airport 2. Design thinking is weak in the building and the focus is on environmental technologies.

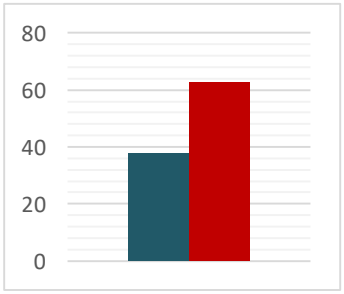


Figure 14.3: Environmental design concepts

14.4 SUSTAINABILITY STRATEGY:

It is clear from the analysis of the sustainability strategy of the three airports that Zayed Airport is superior in terms of energy, environmental quality, communication and innovation, while the percentage of achieving water and waste is lower than the rest of the elements.

The shortcomings in pollution, water and resource operations are clear at Borg El Arab Airport, while the percentage of achieving project management, environmental quality, water and innovation is high.

Water, pollution, energy and water operations are low at Cairo Airport 3, while the environmental resources indicator is not achieved in the building, while the location indicator is achieved at a high percentage due to the location of the project.

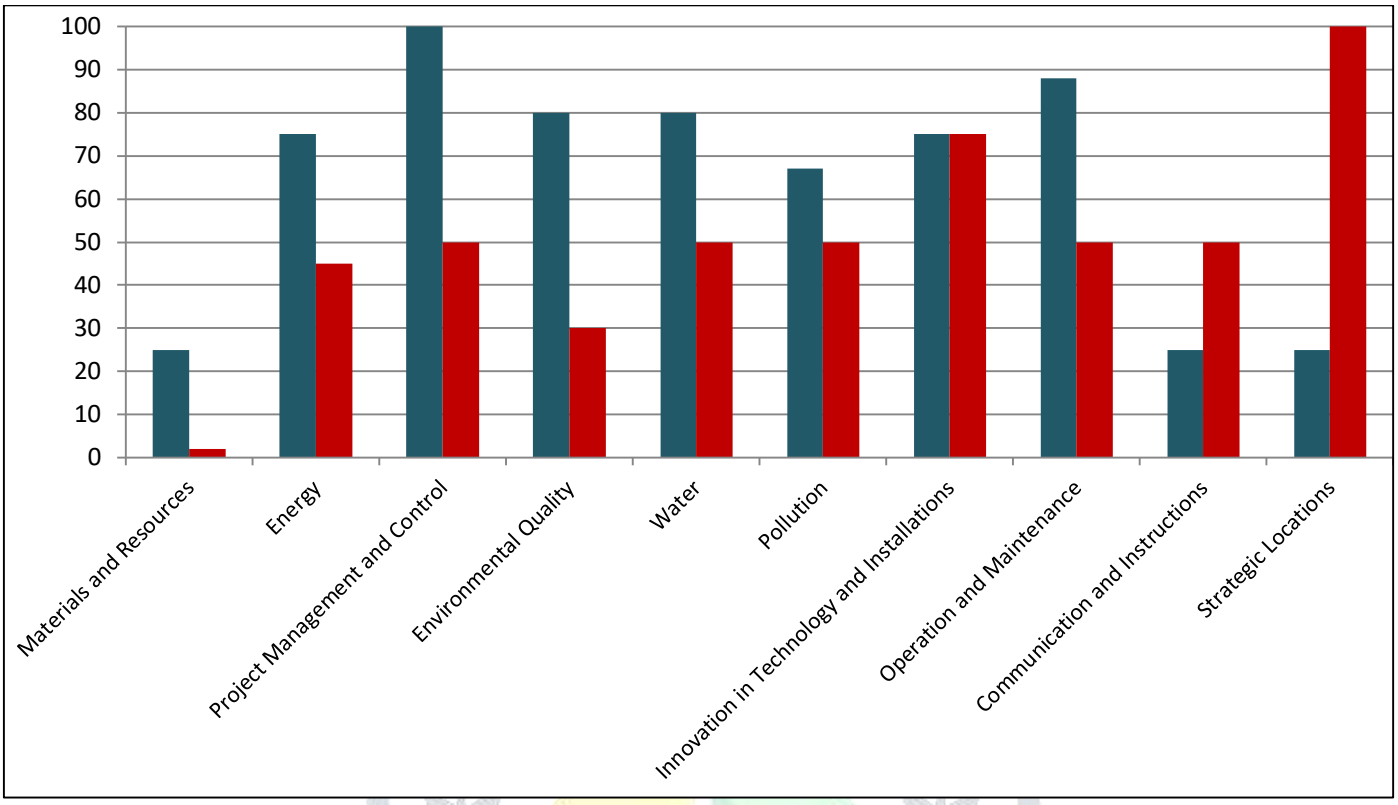


Figure14.4 Sustainability Strategy - in various operations

14.4.1 GENERAL SUSTAINABILITY STRATEGY

Borg El Arab Airport 2 is the first environmentally friendly building in Egypt, achieving a 64% building sustainability rate, which is considered a good rate for Egypt to enter the world of environmentally friendly airports.

Cairo Airport 3 achieved an average building sustainability rate of 50%, and the building needs to be developed, with an attempt to implement it on foundations that are consistent with Egyptian economic, social, cultural and health standards



Figure14.5 General Sustainability Strategy

14.5 TECHNOLOGICAL TECHNIQUES AND THEIR ROLE IN RAISING THE BUILDING'S PERFORMANCE:

The most important points that sustainable design focus on is:

Borg El Arab Airport achieved the highest rate of energy efficiency of 75% and achieved the lowest rate in waste management and focused on carbon emissions.

Cairo Airport focused on water management and energy efficiency compared to waste and emissions management.

Borg El Arab Airport 2 achieved the highest rate in the four departments with a rate of 46.5%, followed by Cairo Airport 3 with a rate of 36.3%.

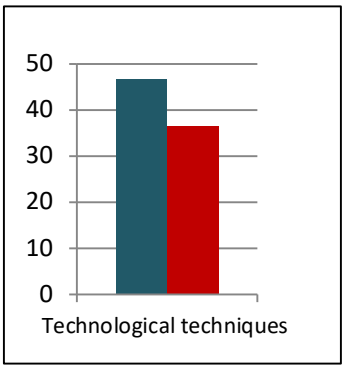


Figure14.6 Technological techniques

The analysis shows that Borg El Arab Airport outperforms Cairo Airport 3 in sustainability points, While Borg El Arab Airport achieves a higher rate in focusing on emissions and Cairo Airport 3 falls short in reaching high rates in sustainable technologies

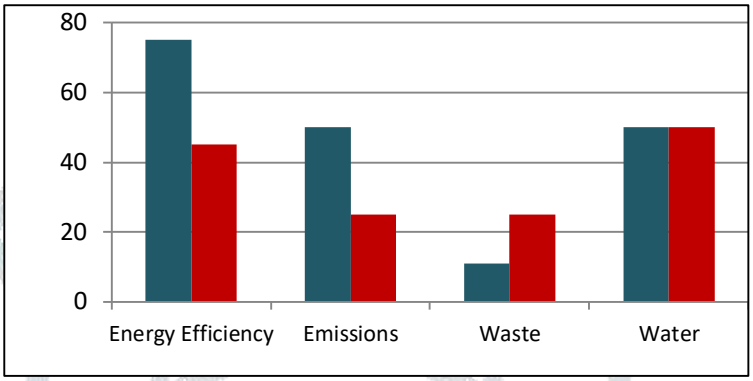


Figure14.7 The range of points that sustainable design focuses on

14.6 MATERIALS AND RESOURCES:

The use of sustainable resources is weak in Cairo-3 and Borg El Arab-2 airports, as most of the materials used are imported, not local.

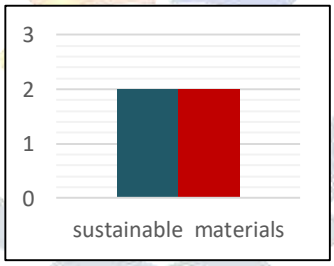


Figure14.8 sustainable building materials

14.7 MAIN DIMENSIONS OF SUSTAINABLE PERFORMANCE:

The environmental dimension at Borg El Arab Airport achieves the highest percentage of 67% and the social dimension is the least affected by the airport's location and the communication between it and the user.

The social dimension at Cairo Airport-3 outperforms both the environmental and economic dimensions by 83% while the deficiency in the environmental dimension remains at 32%.

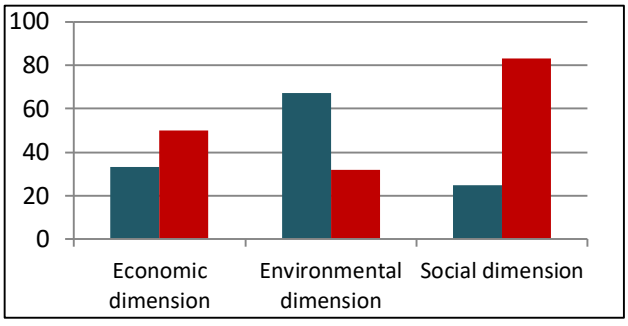


Figure14.9 Analysis of the relationships between the three dimensions (environmental, economic, social)

Cairo Airport-3 outperforms Borg El Arab Airport-2 in overall sustainability performance indicators due to the higher social distance ratio in the airport than Borg El Arab, which is why the overall percentage of sustainability performance indicators is higher**.**

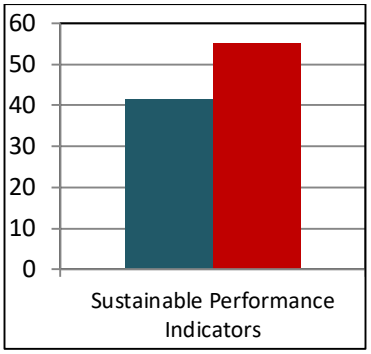


Figure14.10 Sustainable Performance Indicators

14.8 ENVIRONMENTAL TECHNOLOGIES USED TO INCREASE AIRPORT EFFICIENCY:

The limit on energy consumption at Borg El Arab Airport reaches the highest percentage in the airport, reaching 75%, while the use of passive design techniques in the project is lower.

Reducing the demand for energy use represents the highest percentage among the environmental technologies used at Cairo Airport-3, reaching 45%, while the lowest percentage is for passive design, reaching 20%.

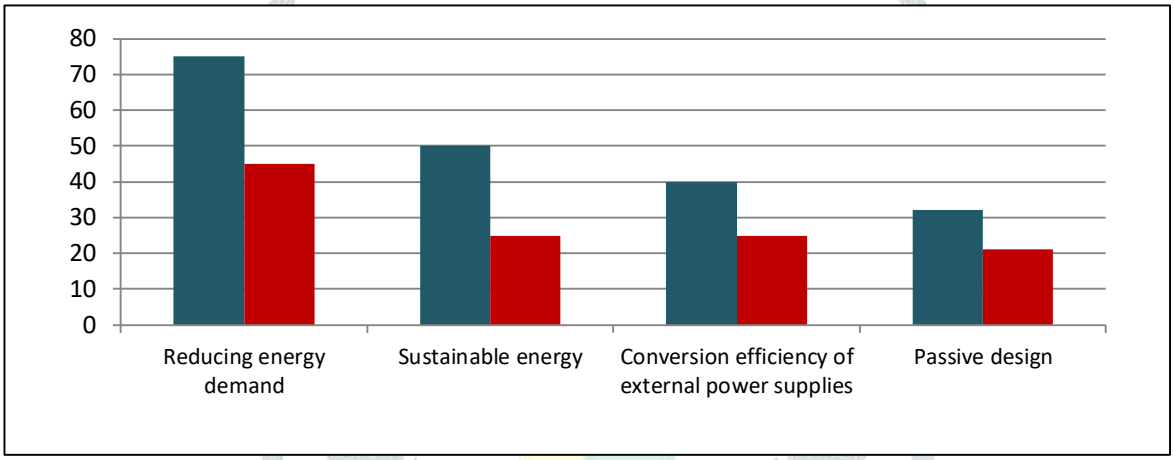


Figure14.11 Environmental technologies used

14.9 GENERAL PERCENTAGE OF ENVIRONMENTAL TECHNOLOGIES

Borg El Arab Airport-2 achieves 49% of the environmental technologies used in the project.

Cairo Airport-3 represents the lowest percentage as it achieved 29% of the environmental technologies used in the building.

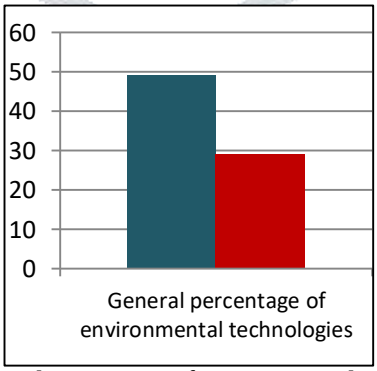


Figure14.12 General percentage of environmental technologies

15. RESULTS AND DISCUSSION

Studies have shown the weakness of environmental standards at Cairo Airport- 3and the extent of interest in taking the required measurements, hence the importance of developing a sustainable environmental strategy to be an approach when establishing and developing Egyptian airports and improving energy efficiency using the value engineering approach due to its role in improving building performance. and the results of each airport building are shown as:

15.1 Cairo Airport Results

The evaluation of the sustainability strategy of Cairo International Airport Building 3 shows the following:

• The strategic location index is excellent due to the airport being located in the city center, as it is located on two main axes, Salah Salem and Nasr Road Axis, and the site is easily accessible by various means of transportation.
• The innovation index in technology and installations at Cairo Airport has recently increased, encouraging innovation in the design and operation of buildings and innovative practices that enhance the efficiency of resource and energy use in the areas of sustainability.
• Cairo International Airport won the award for the best airport in Africa in the category of large airports for sustainable development and the environment for the year 2024-2023, as it was equipped with the installation of a solar power station above the multi-storey garage with a capacity of 300 kilowatts / hour; and the system is being completed at the airport level in successive stages. This confirms the airport's endeavor to reduce energy consumption in successive stages.
• Sustainability in water management is achieved on average, as there is a water station equipped with the latest water purification devices, and a chemical treatment system for cold and hot water, while there are no systems for preserving, collecting, purifying and storing water in tanks, and benefiting from it in cooking, bathrooms, firefighting, irrigation, recycling and using it in flushing boxes and irrigation works.
• The use of sustainable resources and materials or the idea of recycling in the building is not achieved.
• The building reduces harmful environmental impacts and is concerned with reducing the impact of noise, in addition to the presence of a complete sewage network that contributes to improving sewage.
• The design of the building does not achieve the minimum energy consumption and emissions, as energy consumption in the building is large.
• The presence of sensors in space that have the ability to sense the loads of people in terms of increase and decrease and adapt to them to control the temperature through the actual loads of the place, which achieves a small percentage of energy conservation.

• The airport building is interested in service and technical systems (operating the airport) at the expense of the design thought that interacts with and affects the environment.
• The modern technologies used do not depend on environmental solutions that reduce the cost over the life of the project and improve the environmental design thinking of airports.
• Cairo Airport has proven its readiness to accept and apply the latest technology despite the political unrest that has affected the country's work performance in recent period.
• Cairo International Airport won the award for the best airport in Africa in the category of large airports for sustainable development and the environment for the year 2024-2023, and it is the first airport to be equipped with the installation of a solar power station above the multi-storey garage with a capacity of 300 kilowatts / hour; The system is being completed at the airport level in successive stages.

15.2 Results for Borg El Arab Airport

According to the building sustainability strategy, Borg El Arab Airport achieved %72of the building sustainability strategy, the project meets its needs and purpose, and the shortcomings are as follows:

- The indicator for strategic locations is low as it obtained %25, the building does not support electric buses and vehicles (Follow-Me, etc.) and GSE vehicles such as forklift, Toeing tractor and cargo truck inside the airport.
- There are no electric buses to transport passengers from the airport to the station near the Alexandria area, and it is recommended to establish them in the near future.
- The indicator for electrical energy is affected as there is a shortcoming in the use of high-efficiency electrical devices, as there is no Electrical GPU Electrical Ground power Unit and also equipment to control emissions for generators.
- The shortcoming in the materials and resources indicator by %25of the building sustainability strategy, as the use of sustainable and environmentally friendly building materials decreases, in addition to not using recyclable building materials and shortcomings in reducing construction waste and achieving a sustainable life cycle for materials.
- The pollution index is %67due to the lack of waste management, the lack of equipment and/or systems to control and treat waste within the airport, and the provision of internal noise and air pollutant measurement devices in the near future.
- The communication and instructions index is low, which includes ensuring that residents and users of the building are aware of sustainability practices and instructions to make the most of sustainable designs.

16. RECOMMENDATIONS

• Providing specific recommendations for each airport based on the analyzed results and comparisons with advanced international practices.
• Proposing policies and procedures to enhance sustainability, such as adopting clean technology or promoting the use of renewable energy.
• Implementing programs to improve energy efficiency, such as switching to renewable energy sources.
• Improving waste management to reduce negative environmental impacts.
• Analyzing the impact of sustainable initiatives adopted by airports on economic, environmental and social performance.

• The field of sustainable architecture and advanced technology is a vital field that concerns every person and in all environments. It is necessary to increase social awareness of the concept of sustainability and educate about the features of modern technology in the field of construction.
• Adopting factors that enhance the sustainability of airports so that they become more sustainable in terms of health and well-being to meet the needs of all those who interact with them.
• Focusing on energy conservation as a basic requirement through innovative environmental and technical treatments in building systems.
• Improving environmental awareness, training and information exchange.
• Improving the environmental performance of airports by enhancing sustainability and an environmental systems approach.
• Using lessons learned from the sustainability of global airport buildings in some countries.

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