Methodology of Applying Sustainable Design to Achieve Energy Efficiency for Eco-Tourism Hotel buildings in Urban Areas at Siwa Oasis

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Abstract: The world is steadily embracing the concept of sustainability, with a growing focus on incorporating sustainable design principles into building construction—particularly in hotels. This approach aims to improve energy performance and minimize construction and operational expenses by utilizing locally sourced environmental materials. Such practices are especially prominent in urban areas characterized by a unique identity and distinctive style, like the Siwa Oasis. The main objective of this article was to examine the impact of utilizing local materials in buildings within Siwa Oasis on enhancing their energy efficiency. This was achieved through an analytical exploration of structures in the region, complemented by an applied study employing DESIGN BUILDER V 7.0 for buildings in Siwa Oasis. The results indicate an improvement in energy performance in hotel buildings in Siwa Oasis by using local materials by a percentage of approximately more than 14% compared to the base case.

Keywords: Sustainable design - Siwa Oasis - Energy efficiency - Hotel buildings - Local building materials.

1. Introduction

The world is moving towards the idea of sustainability and applying sustainable design standards in the construction of buildings, especially hotels, to improve energy performance and reduce construction and operating costs by using local environmental materials in urban areas with a unique identity and distinctive style, such as the Siwa Oasis. The Siwa Oasis has been known since ancient times as an important trading center, with discoveries in the area indicating human settlements dating back to at least 2000 BC. One of the most prominent landmarks of the oasis is the Mountain of the Dead, which contains three ancient tombs dating back to ancient Egyptian times. and a Roman cemetery containing dozens of rock-cut tombs. In addition. Siwa includes the ancient fortress of Shali, a historical witness to the civilization that flourished in this area. [1], [2] Siwa Oasis stands out as one of the most stunning oases in Egypt, famous for its enchanting natural beauty. It lies in the western region of Egypt. And is characterized by a unique architectural identity that reflects the heritage and authentic culture of the region. [3] The construction of buildings in Siwa Oasis relies on the use of local environmental materials, which plays a major role in preserving the cultural identity of the oasis. In addition, this approach contributes to enhancing environmental and economic sustainability Reducing waste and minimizing the costs of transporting materials from outside the region enhances resource availability. At the same time, it promotes social sustainability by generating job opportunities for local residents and strengthening the local economy. [4] Siwa Oasis is one of the most prominent examples of mud buildings in Egypt. The construction material used is kershief, a material extracted from the shores surrounding the salt lakes. Kershief has properties similar to clay, especially in terms of thermal performance, in addition to containing salt particles. This material also has the ability to provide low-cost and environmentally friendly building techniques due to its lack of carbon emissions. [5] Siwa Oasis is a prime example of sustainable building principles based on local environmental resources. Clay mixed with salt is used to build walls, straw to cover roofs, and wood to make doors and windows, reflecting a natural integration with the surrounding environment. The oasis's environmental design plays a pivotal role in reducing the negative impacts of traditional construction by reducing the carbon footprint and providing natural thermal insulation that suits the nature of the desert climate. In addition, limestone is used to construct walls and columns, with the possibility of adding local decorations that add an aesthetic touch that reflects Siwa's rich cultural heritage and helps preserve its unique identity. Relying on locally available natural materials not only reduces costs, but also ensures effective confrontation with the harsh climatic conditions of the region. This approach not only contributes to sustainable construction, but also positively reflects on promoting eco-tourism in the oasis, as visitors have the opportunity to discover an exceptional architectural style that is a global source of inspiration in the field of sustainability.[6]

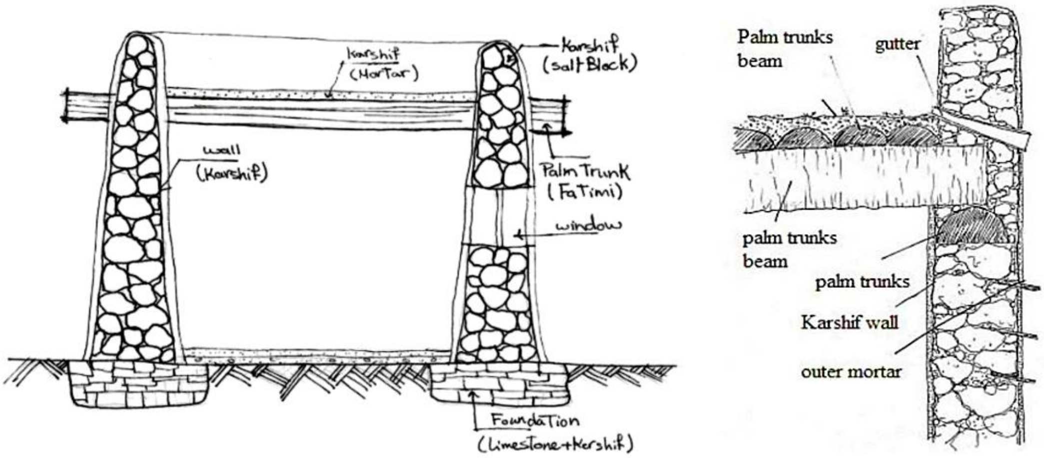


Figure (1) A Section of kershief Walls of building in Siwa Oasis [5], [7]

Research problem:
Not choosing appropriate local materials for the building envelope of hotel buildings in Siwa Oasis increases energy consumption.
Research questions:
How can the energy Efficiency of hotel buildings be improved using local building materials in Siwa Oasis in Egypt?

Objectives:
- Study the effect of using local environmental materials as treatments that enhance the energy efficiency of hotel buildings in Siwa Oasis, Egypt, by utilizing the Design Builder v7.0 simulation program.
- Develop a proposed approach for sustainable design standards to Enhancing energy efficiency in hotel buildings by utilizing local materials found in Siwa Oasis.

Hypothesis:
Local environmental building materials in the building envelope of hotel buildings in Siwa Oasis in Egypt improve energy performance.

2. Methodology:

To accomplish the research objectives, a theoretical approach is adopted, focusing on an in-depth review of prior studies, what has been reached and its impact on the current study and the extent of the need for this study examines the concepts employed and utilizes an analytical approach to determine the optimal model for selecting locally sourced environmental building materials. for hotel buildings in the Siwa Oasis in Egypt, and an applied approach that uses the simulation method through the simulation tool Design Builder v 7.0 program and studying The environmental factors and dominant trends. This was done by using local building materials within the building envelope, efforts focus on enhancing energy performance. This involves analyzing simulation results for each scenario individually and subsequently providing a clear explanation of the findings. And comparing them, thus achieving the research objectives and previous studies and their results. [27], [28]

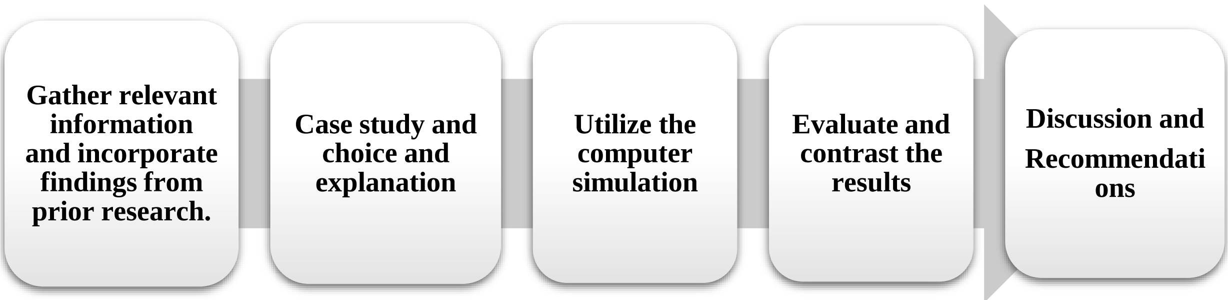


Figure (2) shows the research methodology

3. Literature review:

Global warming and climate change are one of the most important challenges of our time. for which we have not yet found a final solution, and among the critical decisions that will shape the features of the twenty-first century is determining the extent of the efforts that we must make to preserve heritage buildings with a distinctive identity in light of the rapid environmental changes. [11] Siwa Oasis is a site of cultural, biological and ecological significance, and is one of the few remaining oases in the world that still maintains these values and is in exceptional harmony with nature to this day. Siwa is characterized by the presence of plateaus and depressions that embrace many salt lakes and hot sulfur springs, in addition to historical treasures that are evident in the mud buildings that were built long ago. [8] Buildings account for Construction activities account for approximately 35% of global industrial waste and consume 40% of the world's total raw materials, positioning them as a significant contributor to environmental impact. in the depletion of natural resources and increasing energy consumption on the planet. At the same time, The tourism sector has experienced significant growth in recent decades, yet it has not garnered adequate focus from a range of academic and industrial fields.[12] Sustainable tourism that is compatible with biodiversity standards is an ambitious goal that societies seek to achieve due to its many benefits, including providing job opportunities, enhancing local development, encouraging investment in small projects, and empowering local communities, while preserving the environment and biological and cultural diversity in tourist areas. Although sustainable tourism has become a promising market at the global level, Egypt, despite its unique tourism components, especially in the Siwa region, has not yet reached the status that matches its natural, heritage and cultural capabilities. However, the Ministry of Environment is making efforts to support and activate small tourism, which contributes to introducing sustainable tourism and its goals, with a focus on achieving a balance between exploiting and protecting natural resources to ensure sustainable benefits.(9) Interest in applying sustainable design principles more widely in the field of architecture, especially in tourist facilities, due to its important role in contributing to addressing many environmental problems in various parts of the world .(10) The growth of the hotel industry has notably influenced the environment in some areas, as their operation leads to a significant depletion of resources such as electricity and water, to address the requirements for heating, cooling, lighting, and overall operations activities such as laundry. Despite these negative repercussions, it cannot be generalized that all hotels are harmful to the environment. Conscious and responsible management can contribute effectively to preserving the environment and enhancing its sustainability, which positively reflects on the quality of life of the local community. (13) In the hotel sector in particular, the adoption of environmentally friendly materials, the launch of energy-saving programs, wastewater treatment, and the reuse of towels and linens have contributed to significant savings. This comes in response to expectations that global water demand will Increase by 30%, with energy consumption projected to grow by 50% by 2030. Energy consumption rates range from 15 to 90 kilowatt hours per unit. (14) With the continued rise in the realm of electricity, gas, and oil prices, enhancing energy efficiency and striving for energy independence have become key objectives for many hoteliers, particularly when it comes to making investments to promote more sustainable design. (15)

4. Sustainable design:

Sustainable design is an approach to constructing buildings using fewer resources and materials to achieve greater sustainability. This type of design aims to improve improving people's quality of life by providing healthier and more comfortable living and working environments. Buildings create a considerable effect on the environment, responsible for approximately 30 to 40% of overall energy consumption, contributing to global warming. Buildings also produce about half of carbon dioxide emissions in industrialized countries. In addition, the construction sector accounts for about 35 to 40% of the total annual waste in these countries. (16)

Figure (3) shows the Sustainable design [26]

The primary goal of sustainable design has been, and continues to be, to improve the efficiency of the built environment, but this approach alone does not address the greater challenge of global warming. There are some key dilemmas associated with it, including the increasing complexity of achieving efficiency improvements, the difficulty of introducing new technologies into societies that have been built on traditional foundations, and the continued increase in resource consumption rather than its stabilization. Sustainable design focuses on reducing or avoiding the depletion of vital resources, including energy, water, and raw materials such as coal and gas. The greater challenge lies in preventing environmental damage from expanding infrastructure while creating better, more balanced environments at all levels. Sustainable design contributes to reducing negative environmental impacts through thoughtful planning and conscious implementation. It is a concept that can be applied to all areas of design, whether in building construction or manufacturing products. [25]

Sustainable design standards to improve energy efficiency in hotel buildings in urban areas Shows Table (1):

Table Shows (1):Sustainable design standards to improve energy efficiency in hotel buildings in urban areas in Siwa Oasis require taking into account the environmental conditions and cultural specificity of the region, as follows: [17],[18],[19],[20],[21],[22],[23]

	Item	Description	
1	Use of local materials and thermal insulation	- Adopting local building materials such as limestone and clay, known for their excellent properties in natural thermal insulation. - Employing traditional architectural techniques that use thick walls to provide effective thermal insulation.	
2	Passive Design:	- Designing buildings to benefit from natural lighting and ventilation, while reducing their exposure to direct heat. - Creating small windows and high ceilings to reduce excessive heat entry while improving the distribution of natural light.	
3	Enhancing natural ventilation:	- Incorporating ventilation openings that rely on the movement of cold external air through the architectural design. - Using internal courtyards as a source of effective natural ventilation and providing shaded areas.	

4	Green roofs:	- Planting local plants on roofs to reduce heat gain and improve thermal insulation. - Introducing climbing plants on external walls to provide shade and reduce heat absorption. 5- Natural and artificial shading systems: - Planting local trees and using plants to mitigate the effect of direct sunlight. - Designing canopies or pergolas (such as pergolas) from local materials to achieve a balance between shade and beauty.	
5	Natural and artificial shading systems:	- Planting local trees and using plants to mitigate the effect of direct sunlight. - Designing canopies or pergolas (such as pergolas) from local materials to achieve a balance between shade and beauty.	
6	Solar energy:	- Installing solar panels to generate electricity or heat water, in accordance with the surrounding environmental conditions. - Relying on solar water heaters as a sustainable alternative to traditional energy systems.	
7	Natural lighting and thermal efficiency:	- Distributing windows and openings in a way that ensures optimal use of natural lighting throughout the day. - Using double or insulating glass to reduce heat transfer and maintain the coolness of the interior.	
8	Effective cooling systems:	- Applying cooling solutions based on evaporation, such as desert air conditioners, which are suitable for the dry climate of the region. - The possibility of using geothermal cooling techniques if the geological nature supports this.	
9	Insulating roofs and walls:	- Adopting local materials with insulating properties such as plant fibers or rock wool to reduce heat loss. - Adding additional insulation layers to the roofs to enhance the thermal efficiency of the building	
10	Smart energy management systems:	- Installing energy management systems (BMS) to analyze and improve electricity consumption instantly - Using sensors to regulate lighting and air conditioning based on the presence of people inside the building - Effective application of these standards contributes to improving energy efficiency while preserving the traditional character of the area and its environmental characteristics.	
11	Energy-saving devices:	- Using highly efficient electrical devices, such as air conditioning and lighting systems with LED technology. - Providing smart control systems that allow guests to adjust energy consumption based on their needs.	
12	Reducing the effect of urban heat islands:	- Using light-colored materials for building surfaces to reduce heat absorption. - Increasing green areas surrounding the building to improve the quality of the local climate.	
13	Water reuse:	- Collecting rainwater and using it to irrigate plants or for other appropriate purposes. - Treating waste water for reuse in irrigation or cooling systems.	
14	Flexible design:	- Designing multi-use and modifiable spaces to reduce the need for future expansions. - Relying on materials that can be recycled or restored sustainably.	
15	Smart technologies:	- Applying Internet of Things (IoT) systems to enhance energy management efficiency - Providing interactive applications to allow guests to control their energy consumption in a practical and easy way	
16	Education and awareness:	- Raising guests' awareness of the importance of reducing the consumption of resources such as energy and water. - Training employees to adopt and implement best practices to achieve sustainability.	
17	Local partnerships:	- Collaborating with local suppliers to ensure the use of sustainable and environmentally friendly building materials. - Supporting local handicrafts and highlighting them in interior design in a way that reflects the culture of the region	

18	Continuous evaluation:	- Conducting periodic reviews of the performance of energy-related systems within the building. - Improving technologies and processes based on the results and data extracted	
19	Protecting the surrounding environment:	- Avoiding construction work in environmentally sensitive areas to preserve them. - Designing the building in a way that harmonizes with the natural landscape without harming the surrounding environmental balance.	
20	Reducing waste:	- Applying the use of recyclable building materials to reduce waste generation. - Providing modern systems and waste sorting within the hotel to support effective recycling. Commitment	

Developing a design approach to improve energy performance in Siwa Oasis hotel buildings using local materials can be an effective strategy to achieve environmental sustainability and energy efficiency, by taking advantage of environmental conditions and locally available resources Shows Table (2):

Table (2) shows Developing a design approach to improve energy performance in Siwa Oasis hotel buildings using local materials can be an effective strategy to achieve environmental sustainability and energy efficiency, by taking advantage of environmental conditions and locally available resources:

	Item	Description	
1	Site and climate analysis:	- Climate study: Examining environmental conditions in Siwa Oasis, such as day-night temperature differences, humidity, and prevailing wind directions. - Site evaluation: Determining the optimal angles for orienting the building to maximize the use of sun and wind movement.	
2	Selecting appropriate local materials	- Mud bricks: Provide excellent thermal insulation. - Palm wood: Used in making doors, windows, and ceilings - Limestone: Contributes to reducing the temperature of external walls. - Straw and dry grasses: Effective in building roofs, filling gaps, and connecting bricks.	
3	Applying Sustainable design principles	A. Orientation and ventilation - Adjusting the orientation of buildings to reduce direct exposure to the sun - Designing openings and windows to enhance air flow and reduce reliance on mechanical ventilation. B. Thermal insulation - Using thick walls of clay bricks and limestone to increase the effectiveness of thermal insulation - Creating insulated roofs in an innovative way using local materials such as straw and palm wood C. Roof and opening design - Designing high roofs to reduce heat accumulation - Using small mashrabiya openings to achieve shade and ventilation and reduce the entry of direct sunlight. D. Traditional design - Adding internal courtyards to improve ventilation and shading. - Adopting domed roofs to increase natural ventilation and reduce heat attraction.	
4	Relying on simulation programs:	- Using tools such as Design Builder or Energy Plus to simulate energy performance and analyze the impact of local materials and proposed architectural designs. - Comparing energy performance between traditional buildings and those designed according to the new approach.	
5	Performance Evaluation:	- Monitoring energy consumption of cooling, heating and lighting systems. - Measuring thermal comfort by monitoring indoor temperatures and humidity. - Calculating the carbon footprint resulting from the materials used to ensure the extent of emissions reduction.	

6	Continuous development and recommendations:	- Improving designs based on the practical results extracted from the evaluation. - Training local workers on sustainable construction techniques and using locally available resources. - Promoting a culture of sustainability and raising awareness of the role of local materials in improving energy consumption.	
7	Implementing a model project:	- Creating a model of a hotel building in Siwa Oasis that applies the proposed design approach. - Evaluating the energy efficiency and thermal comfort of the model building while conducting an in-depth analysis of the results to encourage the generalization of this approach.	

5. Case Study: Eco-lodge Guest House Project in Siwa Oasis as a Model for Eco-Hotels : (24)

Based on the premise that the building is part of its surrounding environment and cannot be separated from it or separated from it, the French architects Latita Delupac and Christian Felix succeeded in designing a resort in Siwa in 2004-2007, extending over an area of 390 square meters.

The main goal of the design was to achieve complete harmony between the building and its environment so that it appears as if it has been an integral part of it since time immemorial, and it cannot be imagined to exist anywhere other than this location with its distinctive atmosphere and characteristics.

The indigenous people were assisted in the construction process, as the kershief material was used, which a traditional material is made from a mixture of clay, sand and salt dried under the sun, extracted mainly from the salt lakes of Siwa. This choice contributed to enhancing the building's integration with the surrounding natural environment. In addition, the kershief material acts as a natural heat insulator, ensuring that the building's air is moderate in both cold and hot seasons.

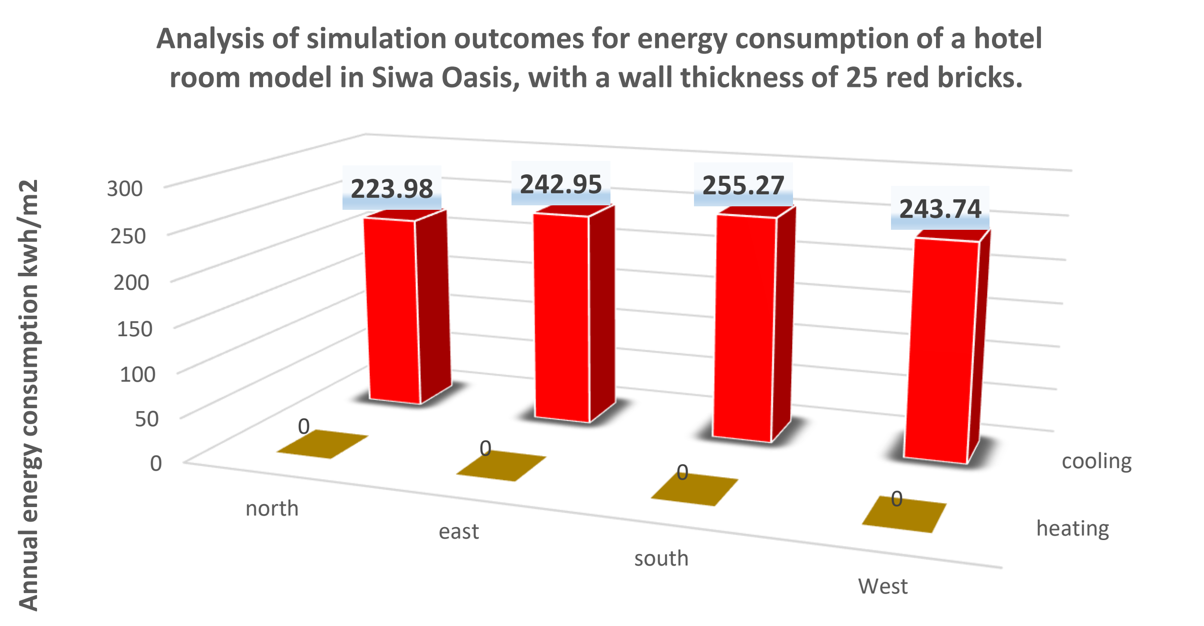
In terms of integration with the environment in the design, the architects decided to abandon modern technology to achieve the main goal of the project; providing a quiet secluded experience for visitors, away from the noise of modern life, to enjoy the simplicity of the surrounding environment. Therefore, electricity was dispensed with and instead, candle lighting was relied upon. The thick walls made of kershief were designed to be suitable for placing candles, and the lit chandelier was used in the same way. Even the sewage system was treated in simple ways within the palm grove and reeds, reflecting complete harmony with nature.

Figure (4) shows a guest house in Siwa Oasis. (29)

Discussion of the Results reducing energy usage while enhancing its efficiency through the use of local materials in Siwa Oasis using the DesignBuilder v 7.0 simulation tool:

Through the simulation program, the rate of reducing energy consumption and improving energy efficiency was measured using the wall thickness of local materials and the difference in orientation. This will be explained as follows:

Case 1: Simulation of energy consumption rate and energy efficiency improvement was conducted when utilizing a red brick wall with a thickness of 25 cm with different orientations as shown in Figure (5):

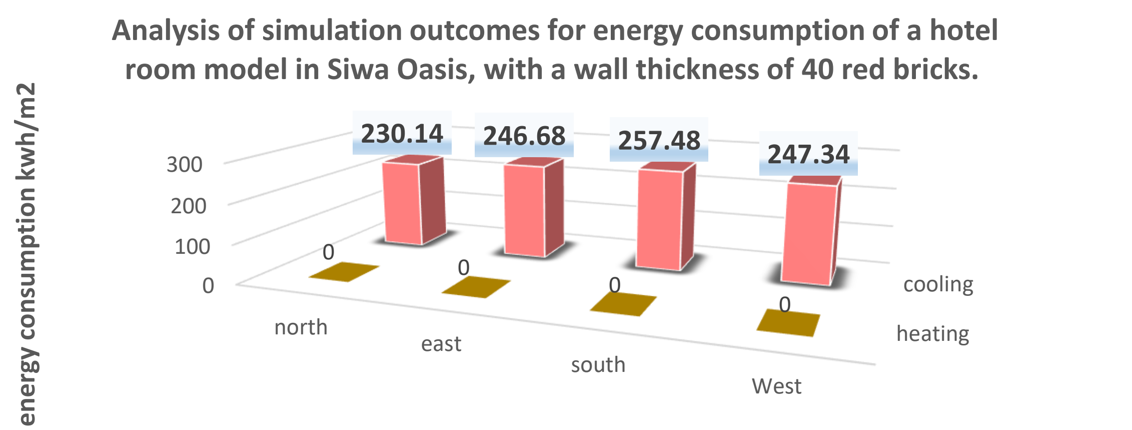


	north	east	south	West
heating	0	0	0	0
cooling	223.98	242.95	255.27	243.74

Figure (5) First case: Shows the results of simulating the energy consumption rate when using a 25 cm thick wall made of red bricks, featuring different orientations for hotel rooms in the Siwa Oasis.

The results of Figure (5) showed that there is a difference in energy consumption and efficiency based on the orientation. The highest energy consumption rate was in the southern orientation, reaching 255.57 kWh/m² per year at the specified wall thickness. In contrast, the lowest energy consumption rate was for the northern orientation, reaching 223.98 kWh/m² per year, indicating a decrease of 8.10% in comparison to the southern orientation. As for the western orientation, the annual energy consumption rate was 243.74 kWh/m², while the eastern orientation recorded a similar rate at 242.95 kWh/m².

Case 2: Simulation of energy consumption rate and energy efficiency improvement was conducted when utilizing a red brick wall with a thickness of 40 cm with different orientations as shown in Figure (6):

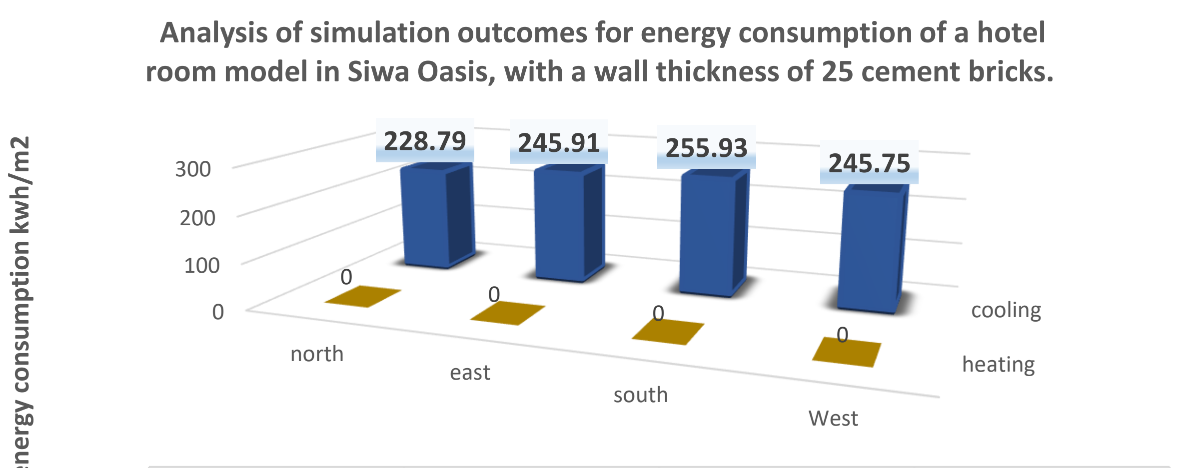


	north	east	south	West
heating	0	0	0	0
cooling	230.14	246.68	257.48	247.34

Figure (6) First case: Shows the results of simulating the energy consumption rate when using a 40 cm thick wall made of red bricks, with different orientations for hotel rooms in the Siwa Oasis.

The results of Figure (6) showed that there is a difference in energy consumption and efficiency based on the orientation. The highest energy consumption rate was in the southern orientation, reaching 257.48 kWh/m² per year at the specified wall thickness. In contrast, the lowest energy consumption rate was for the northern orientation, reaching 230.14 kWh/m² per year, indicating a reduction of 7% in comparison to the southern orientation. As for the western orientation, the annual energy consumption rate was 247.34 kWh/m², while the eastern orientation recorded a similar rate at 246.68 kWh/m².

Case 3: Simulation of energy consumption rate and energy efficiency improvement was conducted when utilizing a cement brick wall with a thickness of 25 cm with different orientations as shown in Figure (7):

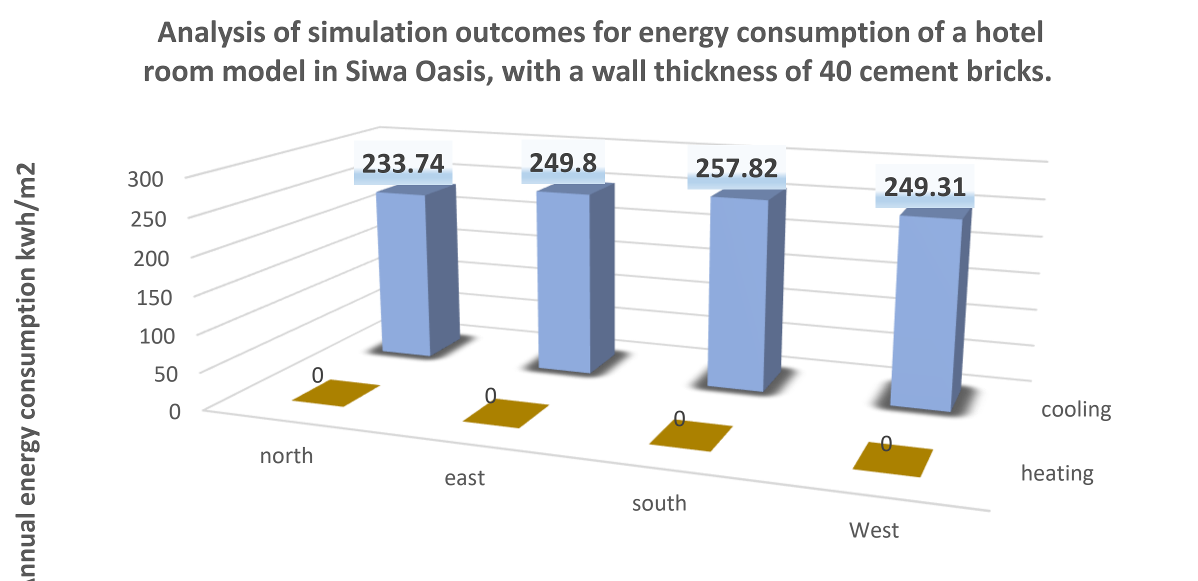


	north	east	south	West
heating	0	0	0	0
cooling	228.79	245.91	255.93	245.75

Figure (7) First case: Shows the results of simulating the energy consumption rate when using a 25 cm thick cement bricks wall, with different orientations for hotel rooms in the Siwa Oasis.

The results of Figure (7) showed that there is a difference in energy consumption and efficiency based on the orientation. The highest energy consumption rate was in the southern orientation, reaching 255.93 kWh/m² per year at the specified wall thickness. In contrast, the lowest energy consumption rate was for the northern orientation, reaching 228.79 kWh/m² per year, indicating a decrease of 10.6% in comparison to the southern orientation. As for the western orientation, the annual energy consumption rate was 245.75 kWh/m², while the eastern orientation recorded a similar rate at 245.91 kWh/m².

Case 4: Simulation of energy consumption rate and energy efficiency improvement was conducted utilizing a cement brick wall with a thickness of 40 cm with different orientations as shown in Figure (8):



	north	east	south	West
heating	0	0	0	0
cooling	233.74	249.8	257.82	249.31

Figure (8) First case: Shows the results of simulating the energy consumption rate when using a 40 cm thick cement bricks wall, with different orientations for hotel rooms in the Siwa Oasis.

The results of Figure (8) showed that there is a difference in energy consumption and efficiency based on the orientation. The highest energy consumption rate was in the southern orientation, reaching 257.82 kWh/m² per year at the specified wall thickness. In contrast, the lowest energy consumption rate was for the northern orientation, reaching 233.74 kWh/m² per year, indicating a decrease of 9.34% in comparison to the southern orientation. As for the western orientation, the annual energy consumption rate was 249.31 kWh/m², while the eastern orientation recorded a similar rate at 249.8 kWh/m².

Case 5: Simulation of energy consumption rate and energy efficiency improvement was conducted utilizing limestone brick wall with a thickness of 25 cm with different orientations as shown in Figure (9):

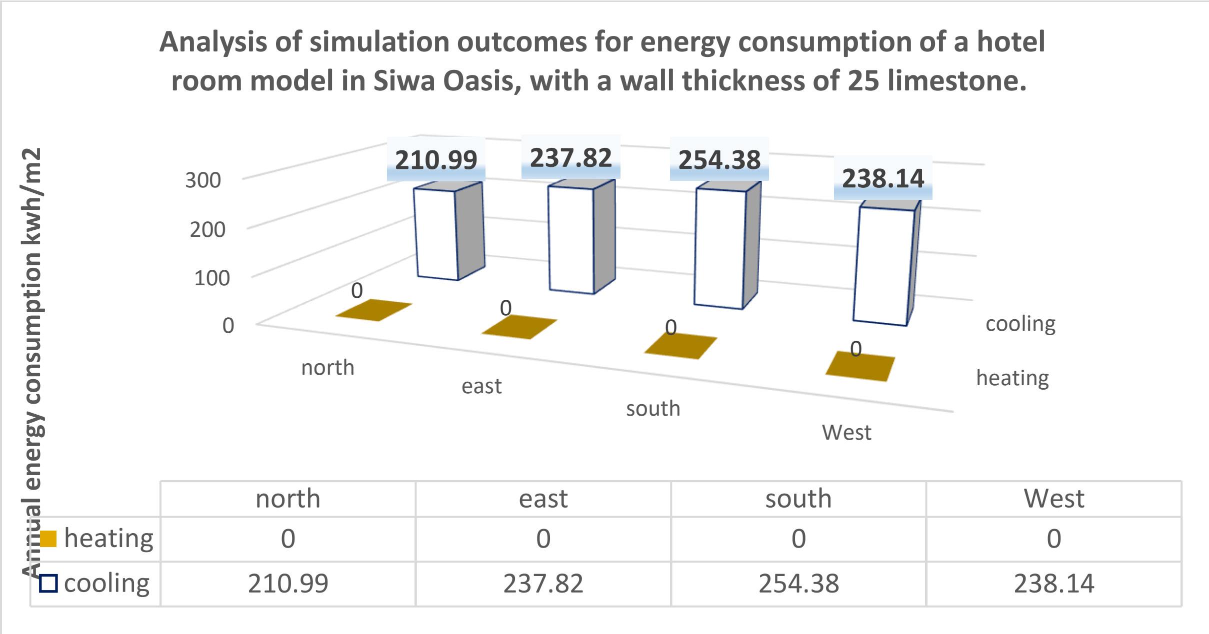


Figure (9) First case: Shows the results of simulating the energy consumption rate when using a 25 cm thick limestone bricks wall, with different orientations for hotel rooms in the Siwa Oasis.

The results of Figure (9) showed that there is a difference in energy consumption and efficiency based on the orientation. The highest energy consumption rate was in the southern orientation, reaching 254.38 kWh/m² per year at the specified wall thickness. In contrast, the lowest energy consumption rate was for the northern orientation, reaching 210.99 kWh/m² per year, indicating a decrease of 17.1% in comparison to the southern orientation. As for the western orientation, the annual energy consumption rate was 238.14 kWh/m², while the eastern orientation recorded a similar rate at 237.82 kWh/m².

Case 6: Simulation of energy consumption rate and energy efficiency improvement was conducted utilizing limestone brick wall with a thickness of 40 cm with different orientations as shown in Figure (10):

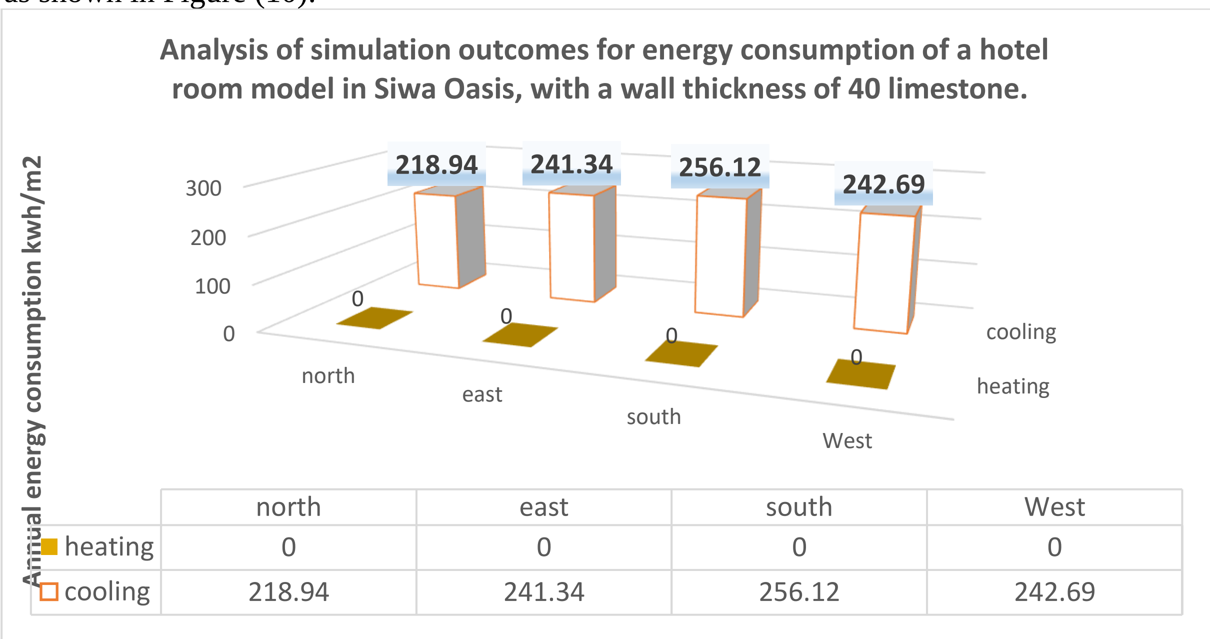
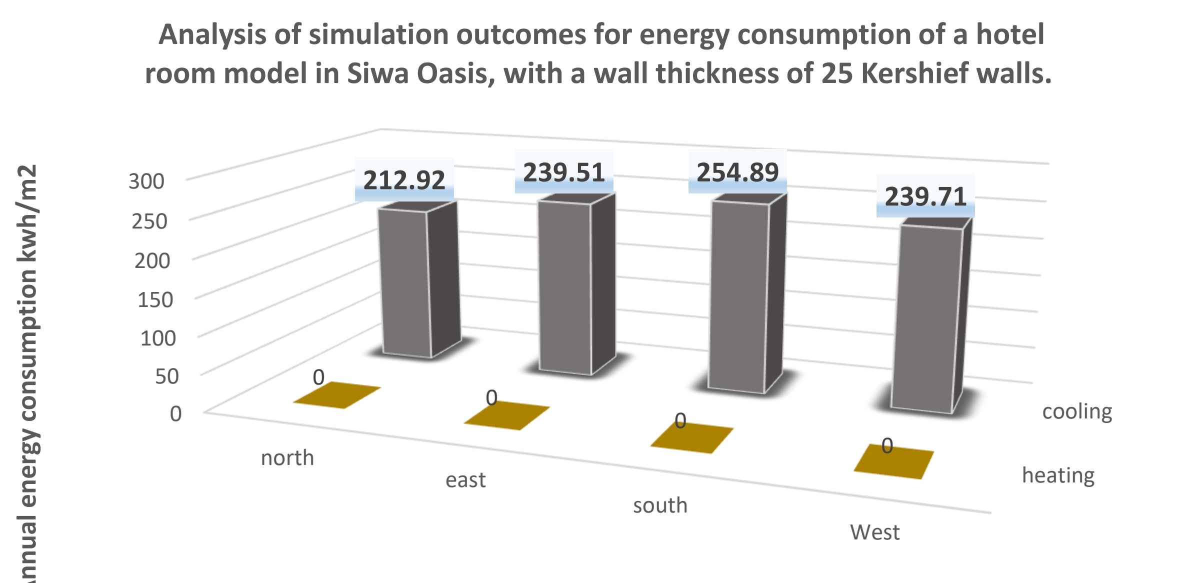


Figure (10) First case: Shows the results of simulating the energy consumption rate when using a 40 cm thick limestone bricks wall, with different orientations for hotel rooms in the Siwa Oasis.

The results of Figure (10) showed that there is a difference in energy consumption and efficiency based on the orientation. The highest energy consumption rate was in the southern orientation, reaching 256.12 kWh/m² per year at the specified wall thickness. In contrast, the lowest energy consumption rate was for the northern orientation, reaching 218.94 kWh/m² per year, indicating a decrease of 9.8 % in comparison to the southern orientation. As for the western orientation, the annual energy consumption rate was 242.69 kWh/m², while the eastern orientation recorded a similar rate at 241.34 kWh/m².

Case 7: Simulation of energy consumption rate and energy efficiency improvement was conducted utilizing kershief brick wall with a thickness of 25 cm with different orientations as illustrated in the figure (11):

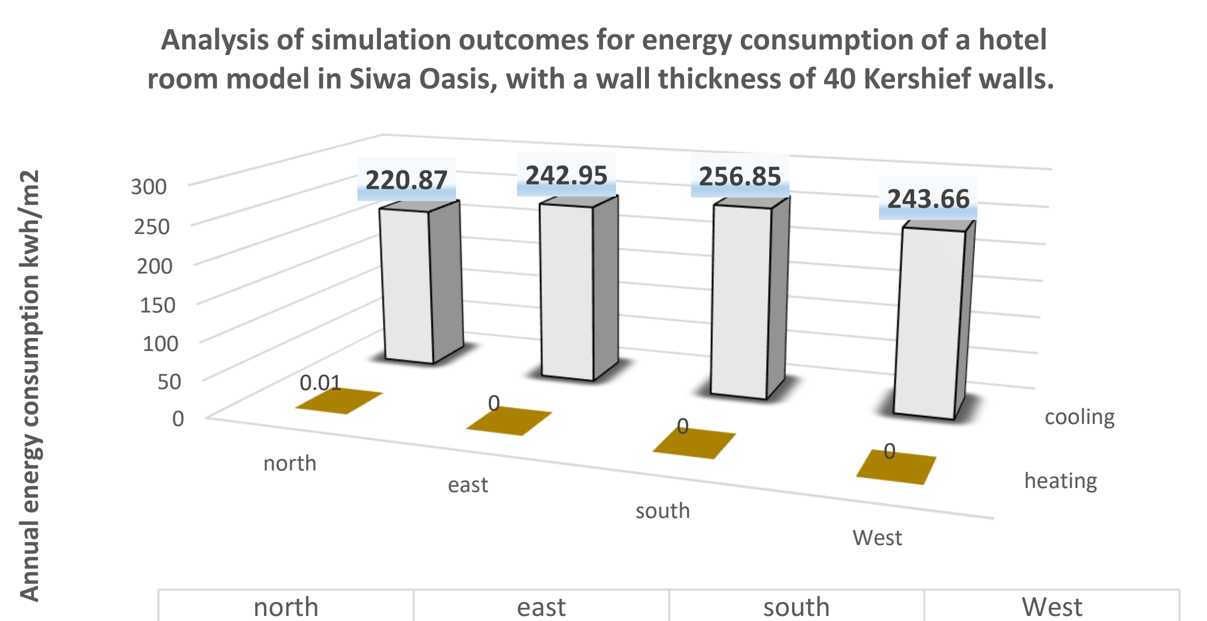


	north	east	south	West
heating	0	0	0	0
cooling	212.92	239.51	254.89	239.71

Figure (11) First case: Shows the results of simulating the energy consumption rate when using a 25 cm thick Kershief walls, with different orientations for hotel rooms in the Siwa Oasis.

The results of Figure (11) showed that there is a difference in energy consumption and efficiency based on the orientation. The highest energy consumption rate was in the southern orientation, reaching 254.89 kWh/m² per year at the specified wall thickness. In contrast, the lowest energy consumption rate was for the northern orientation, reaching 212.92 kWh/m² per year, indicating a decrease of 11.17% in comparison to the southern orientation.. As for the western orientation, the annual energy consumption rate was 239.71 kWh/m², while the eastern orientation recorded a similar rate at 239.51 kWh/m².

Case 8: Simulation of energy consumption rate and energy efficiency improvement was conducted utilizing kershief brick wall with a thickness of 40 cm with different orientations as shown in Figure (12):



	north	east	south	West
heating	0.01	0	0	0
cooling	220.87	242.95	256.85	243.66

Figure (12) First case: Shows the results of simulating the energy consumption rate when using a 40 cm thick Kershief walls, with different orientations for hotel rooms in the Siwa Oasis.

The results of Figure (12) showed that there is a difference in energy consumption and efficiency based on the orientation. The highest energy consumption rate was in the southern orientation, reaching 256.85 kWh/m² per year at the specified wall thickness. In contrast, the lowest energy consumption rate was for the northern orientation, reaching 220.87 kWh/m² per year, indicating a reduction of 14% in comparison to the southern orientation. As for the western orientation, the annual energy consumption rate was 243.66 kWh/m², while the eastern orientation recorded a similar rate at 242.95 kWh/m².

6. Recommendation:

- Interest in applying sustainable design principles more widely in the field of architecture, especially in tourism facilities, because of its important role in contributing to addressing many environmental Challenges in various regions of the world are addressed through close collaboration between governmental entities and the private sector. And civil society.
- It is necessary to build an integrated system based on a pillar that includes the social, economic, and environmental aspects. This is tangibly demonstrated in the focus on developing sustainable hotels as a means of meeting the needs of the local community and supporting the economy while respecting the environment.
- On the other hand, it is necessary to set clear environmental standards for sustainable hotels and work to generalize them in the tourism sector, especially in Egypt. These efforts can be enhanced by applying the Egyptian Green Building Code known as the Green Pyramid, which is considered an effective tool for reducing energy consumption in hotel buildings. It is also a call to use local materials such as Kershief, a practical step to improve energy performance.
- Encouraging investment in the establishment of sustainable hotels is a major incentive to achieve this vision. This requires providing financial incentives to investors and supporting initiatives that promote the concept of environmentally friendly hotels. It is also important to

update laws and specifications related to construction to ensure their compatibility with sustainable design principles.
- The culture of sustainable design needs to be enhanced by raising community awareness through continuous awareness campaigns targeting various stakeholders in the hotel sector. Providing training programs for hotel workers on how to apply these principles is essential to advance this sector.
- Supporting research and development plays a pivotal role in promoting innovation, whether in construction techniques or the utilization of contemporary materials to enhance environmental sustainability. performance of different categories of hotels.

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