Towards a Strategy for Designing Sustainable Zero-Energy Buildings Using Building Information Modeling (BIM)

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Abstract: Environmental studies and reports have indicated the threat to the environment and their repercussions on humanity. The urgent need has emerged for creative ideas to work on confronting these dangers, and therefore calls have been raised to create a sustainable approach in all sectors. This resulted in the emergence of modern and advanced technologies in project management, which is an important stage for the transition to a more prosperous future in the world of construction, the most important of which is the Building Information Modeling (BIM) technology, which constitutes a radical transformation in the field of engineering projects, which means designing a model of the building, including all its information and data. The research aimed to develop a specific strategy for designing sustainable zero-energy buildings using Building Information Modeling (BIM). The research adopted the analytical approach and the case study approach by analyzing the theoretical ideas related to the concept of building information modeling technology and integrating the sustainable design strategy with this technology and achieving zero-energy buildings. The research study aims to integrate sustainable design strategies and concepts into BIM technology and harness the potential of BIM technology in facilitating sustainable design solutions to achieve zero-energy buildings. Methods for choosing the best methods to achieve zero architecture and the effect of building materials, thermal insulation, and type of glass on the thermal performance of the residential building in the hot dry climate, especially in the Greater Cairo region. Study of Sakan Masr units for workers' housing in the New Administrative Capital, using the computer and simulation programs. This part studies the effect of different building materials, thermal insulation, and types of glass on energy efficiency in residential buildings.

Keywords: Strategy, Design, Sustainable Buildings, Zero Energy, Building Information Modeling Technology.

1. Introduction

Egypt's Vision 2030 is based on the principles of comprehensive sustainable development that guarantee an integrated and sustainable environmental system that aims to preserve development and the environment together through the rational use of resources, increasing reliance on renewable energy, and adopting sustainable consumption and production patterns. Zero-energy architecture is one of these sustainable trends as one of the solutions to these environmental problems and the trend towards adopting the idea of the zero-energy school as the nucleus for sustainable communities and as one of the approaches to achieving sustainable development.

Building information modelling (BIM) is one of the most significant developments in engineering in its various fields, Using BIM technology, an accurate visual model of the building is created. This model, known as the building information model, is used in the planning, design , construction and operation processes of the project, and helps engineers visualize what will be built in a virtual simulation environment to determine the optimal alternatives for design, construction and all elements related to operation and BIM as a new approach in various fields of engineering (AEC) works on Integration of the roles of project parties [1].

The "Building Information Modeling" approach is an integrated system that includes everything related to the project and places it in one template. It represents a central database that feeds all parties to the project and includes all project documents, whether they are schemes, tables of quantities, specifications, or the timetable for implementing the project work. It provides users with accurate and available information during the project stages, and all the functions necessary to complete the building through a virtual electronic model that simulates reality. These systems have become commonly used by project parties during their life cycle, such as the owner, contractors, designers, and project managers, as shown in Figure (1-1) [2].

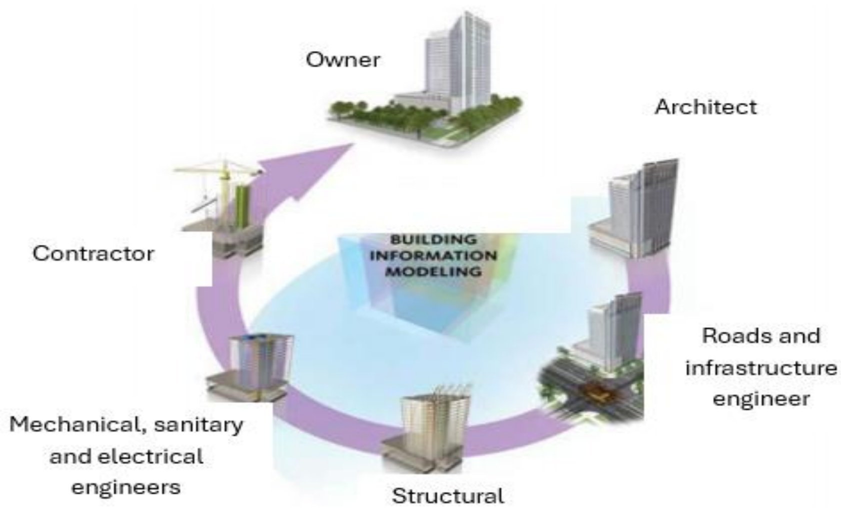


Figure 1. Building information modelling systems commonly used for project parties ([2])

BIM is an abbreviation of Building Information Modeling, which means the design of a building model that includes all its information and data and the meaning of a model here that goes beyond the concept of 3D-shaped abstract construction. Here is a simulation and characterization of each process that the building passes through during its construction on the ground, which includes its construction as a 3D virtual form. It has its characteristics that we can introduce, , and also includes perceiving it with the time factor (4D), introducing the cost factor (5D), the sixth factor (6D) is sustainability, and the seventh factor (7D)and the last is managing the project after completion of its implementation and taking care of its maintenance and other matters that occur to the building in the future[3].

The American Institute of Architects (AIA) has defined BIM systems as Building Information management as the process that provides the benefits that appear clearly through the electronic model and includes centralization of information and visual communication of building elements, sustainability, efficient integration between various disciplines, quality control, site organization, and more accurate operational schemes. "[4]

2 .BENEFITS OF USING BUILDING INFORMATION MODELING (BIM).

2 .1 .Design Stage

-Coordinating the teamwork of all members of the project team simultaneously, which achieves integration between all engineering disciplines.

-Early detection of design errors and ease of modification, saving time and reducing errors as modifying one element is done on all drawings at the same time.

-Quantifying the quantities and specifications of materials involved in construction, calculating the initial cost, simulating the shape of the building, and analyzing its sustainability and environmental comfort.

2.2. Implementation Stage

-Detecting potential problems, proposing possible improvements to them, and detecting conflicts between the structural and finishing elements with each other.

-Use a virtual model to simulate the implementation process, and help choose the best implementation methods.

-Coordination between the work team, and flexibility in documents and outputs.

2. 3. Post-implementation Stage

-Simplifying information exchange and cooperation between the building operating team and achieving successful information management.

-Achieving sustainability in the operation of the building and controlling its internal environment.

- Alerting project management to emergency deficiencies or those that require maintenance and restoration and working to schedule them [5].

3 .THE ROLE OF THE BIM MODEL IN THE PRODUCTION DIMENSION OF THE DESIGN PROCESS

The BIM model expresses a digital description of the real building, including the spaces, functions and specifications of the finishing materials used and mechanical systems, as well as the method of supplying these materials and systems and the various stages of construction, and tracking the cost and time required to implement the project. This digital model has a set of Properties.

3 .1 .Primary Design

The initial design stage represents the first stage of the production dimension of the design process, during which a set of design alternatives are formulated that aim to solve the problem. BIM applications are essentially applications for 3D modelers, through which a set of alternatives can be made in a three-dimensional image. In addition to this, these applications can extract a set of information for each model, whether areas, volumes, structural proportions, or the functional program achieved in each model, which helps in the process of evaluating these alternatives and choosing the most appropriate among them.

The developers of these applications have integrated a set of tools and means that contribute to the process of unconventional digital thinking by using mathematical equations and modeling using Parametric Design formulas. This is done through the Parametric Engine, with which Autodesk supported its latest versions of the Revit program, and this engine is based on Parametric Algorithms that are written using Scripting Languages, this method was used in formulating the architectural formation of the Ocean Heights towers in the United Arab Emirates.

3 .2 .Primary Sketch Design

This is the stage of settling on the proposed solution, where it is modeled in three dimensions, and the BIM model plays an important role in conducting the simulation process for the factors affecting the design with the aim of testing and developing it and improving its suitability to environmental and climatic conditions and factors, through a group of applications that use the necessary analyzes to measure the efficiency of the systems' performance inside the building by integrating the information and data necessary for analysis through the BIM model, and there are many analysis applications that work in a simulation manner, which work on analyzing different fields, whether sound, light, thermal, or others, and the most important and famous of them are in the simulation process.

3 .3 .Detailed Design

It is the most important and final stage of the productive dimension of the design process, as this stage is considered the preparatory stage for the implementation process, during which the full executive and detailed drawings of the design are prepared. The largest and most important role of the BIM model appears in this stage, due to the large number of activities in it, and the breadth of the engineering work team from Various disciplines, and the BIM model provides these advantages to the design process [6].

4 .Sustainable architecture and BIM technology

The trend towards sustainable architecture has emerged as a response to the impacts of the building construction sector on the surrounding environment and primary sources. Sustainable buildings refer to the achievement of quality standards, sustainability principles and strategies, high levels of efficiency in the use of energy and water resources, appropriate use of land and site coordination, and the use of environmentally compatible building materials to achieve environmental quality, Interior water efficiency, reducing the impacts of buildings during their life cycle, and solid waste management [7]. The process of creating sustainable buildings begins with considerations of choosing the site, the effects of the building on the surrounding environment, the energy consumed by the movement of users, the impact on local ecosystems, and the impact on infrastructure, while respecting historical considerations and the general character of the site.

Sustainable architecture is based on a set of principles that include rationalizing the consumption of materials and sources, reusing them, using recyclable sources, protecting the environment and focusing on quality. The sources have been defined as the exploitation of land, building materials, water, energy, and the quality of the indoor environment in addition to ecosystems. The sustainable architecture system is completed by applying these principles during the evaluation of components and resources during the entire life cycle of the building, which includes the stages of design, construction, occupancy, and operation, until the final disposal stage, which refers to the dismantling of the building instead of its demolition [8].

Building Information Modeling (BIM) can also help in conducting complex building performance analyzes to design a sustainable building, as the use of Building Information Modeling (BIM) provides multiple ways to increase and enhance the quality of interior design and architecture projects at the level of design, implementation, facilities management, maintenance and operation, and contributes to the preparation Controlling schedules, bills of quantities, and specifications with extreme precision, and reducing overall project costs [9].

The current research aims to evaluate the use of BIM technology in the fields of interior design, architecture and building engineering in its support of sustainable design and construction, and to explore the suitability of BIM for sustainability analysis by developing a conceptual framework that explains how the interior designer and architect can use BIM to analyze sustainability and evaluate leadership in the field of energy and environmental design LEED for all parts of the building.

The relationship between BIM and sustainability is permanent because BIM achieves and documents the extent to which sustainability can be applied, which meets the needs of humans at the present time without compromising what the new generations need. This is done by improving the building design and construction processes through a model rich in information, and sustainable designs begin with the philosophy that the definition of a well-designed building automatically includes characteristics that constitute sustainability. These include choosing the most environmentally friendly sites, water conservation, optimal energy use, attention to life cycle assessment of materials, and indoor environmental quality. It also means taking a personal stance that all design work undertaken will meet specific performance standards [1].

5 .Potential of Building Information Modeling in Sustainable Design

The uses of Building Information Modeling (BIM) and its applications in achieving sustainable design concepts are divided into three main axes:

5. 1. Building formation (building orientation, building mass, natural lighting).

5. 1. 1. Orientation of the building

The need to know the geographical location of the project, the direction of the north and the prevailing wind, and the correct orientation is the guide to many sustainable design strategies. After determining the goal of proper orientation, we need to apply that to the model. This can be done simply by using the building information model environment. and by specifying the project location and determining the city, latitude and longitude are determined by the appropriate building angle, and you can see on the model the effects of the correct orientation of the building, and the correct orientation is the one that gives a lower percentage of the gained energy [10].

5. 1. 2. Building Mass

Determining the shape and size of the building mass is affected in the building information model in order to compare it with the advantages and disadvantages of other shapes that will be deduced, which must have the same basic values (number of users, operating schedule, lighting, air conditioning and ventilation systems, outer shell systems...etc.) So that they can be compared, and when you change the shape of the block, other things will change, such as the size of the building and the amount of external walls, and these values will also have an impact on the cost of construction, heating and cooling, and the loads of the building, and to ensure consistency during the comparison, you set some parametric values that we want to maintain. Thus, we can obtain a large number of alternatives to the block shape, which allows flexibility in choosing the best solution and measuring the extent of success of some alternatives in providing more sustainable solutions [10].

5. 1. 3. Natural Lighting

Natural lighting is used to illuminate buildings, in addition to making people more comfortable and productive. It reduces the artificial lighting load, thus reducing internal heat gain and energy use. High-performance sustainable design derives most of its ultimate success from the effective relationship and integration with the sun's energy in the design of the external envelope, while it is rare to achieve efficient natural lighting due to the complexity of the mathematical operations required to analyze the precise properties of natural lighting. In previous years, there were computer programs available that could perform these tasks, but they were difficult to use due to the difficulty of entering design information, while with the use of building information modeling (BIM) applications the design team is able to represent, measure and document complex natural lighting interior design within a standard design environment [11].

5. 2. Building systems (energy modeling, use of renewable energy, water rationalization).

5. 2. 1. Energy modeling

It depends on energy modeling, which varies in complexity and compatibility with the building information model and levels of detail. The appropriate tool for analysis depends on the designer, his skill, his ability to understand the results, the time available, and the current stage of the project. For example, the Revit program is directly linked to the Green Design Studio (GBS), which is one of the Autodesk applications and performs Energy analyzes for buildings on the Internet, where the Green Design Studio provides a correct thermal engineering model for the building, applies the assumptions of the standards and code, performs analysis operations, and then returns a summary of the results to the designer [11].

5. 2. 2. Use of renewable energy sources

One of the most commonly used sources is the sun and wind, but to obtain the greatest benefit from renewable energy systems, you must use the correct system. Choosing the correct sources of renewable energy depends mainly on the location, climate, location, and availability of these sources, in addition to a group of other factors that must be taken into account. considerations (such as efficiency, maintenance, the space needed by the system...etc.), and after verifying the capabilities of the systems, we use building information modeling (BIM) to help us orient the building correctly, calculate potential energy returns, and calculate feasibility studies for each system. We add design to the model to improve its performance, and at all stages of design there are a number of ways to achieve the greatest amount of renewable energy [12].

5. 2. 3. Water rationalization

The focus of sustainable design is mostly directed towards reducing energy consumption, while water is one of the most important natural resources for human life, and there are many strategies that have been developed to allow us to reduce our water needs (such as more efficient equipment, rainwater harvesting, water reuse garner, Maintenance...etc.), some of which can be applied by entering the building information model into one of the building's energy and water consumption monitoring programs. There are not yet BIM applications that combine climate information and building systems, so three different tools are used to collect and information analysis [12].

5. 3. Building construction (use of sustainable materials, cost, implementation planning).

5. 3. 1. Use sustainable materials.

The selection of building materials is important in the sustainable design process, and when a decision is made to choose a specific material, many questions arise about the many diverse effects of materials, which can be answered through the life cycle of the materials with regard to manufacture, installation, use, and the end of the life cycle of the selected materials, and there are many considerations when choosing materials, they include reducing energy and water consumption throughout their life cycle, their effects on the environment and human health, the efficiency of the indoor environment, performing the function efficiently for at least a hundred years, and the ability to renew and recycle.

The Building Information Model helps in many points to obtain the LEED Certificate for Sustainable Design (calculation of areas, volumes, assembly cost, accreditation materials), and applying for this accreditation requires the registration of each material or product used to obtain the various credits that show that the project integrates the percentage required for the reuse and recycling of materials, the use of local sources and the ability to quickly renew, and the estimated cost of the project is easily determined using the model in conjunction with the calculation of quantities of materials [13].

6. The importance of building information modeling technology in sustainable design

1- Formulating a approach that proposes achieving the integration of sustainable design strategies and concepts into BIM technology by studying the concepts of both the building information model and sustainable design and identifying the tools required to make the model, , the tools that are used to analyze building performance and the capabilities offered by the model to achieve sustainable design, as it enables architects to develop and study multiple design alternatives in sync with the model, with the possibility of visual visualization, measurement and analysis of sustainable design options, and to present new characteristics of the building such as energy and full life cycle cost for the building to evaluate it and reach the optimal solution, and make the information required for sustainable design and for projects to obtain LEED certification to be provided periodically, analyzed, easily examined and documented completely within the building information model simply during the stages of the design process.

2- It was suggested that performance analysis and simulation tools, specification management tools, model auditing and selection tools be integrated directly into BIM applications and tools, that is, the possibility of developing applications for building information modeling that do all of these tools together, from creating a building information model with all the details of the building and conducting studies on sustainability so that BIM technology becomes itself a tool for analysis.

3- Prediction through some technical visions and future possibilities of building information modeling and its tools and capabilities in facilitating sustainable design solutions, which have not yet crystallized in their true sense and are still postponed to the future, the most important of which are: integrating carbon analysis and calculations, and building information modeling (BIM) applications that combine information Climate and building systems, and a new relationship between the designer and the building information model, developing the engineering building model import process [14].

7. Principles of Zero Energy Buildings

The American Society of Heating, Refrigerating and Air-Conditioning defines zero energy buildings as: buildings designed to achieve a balance between low energy consumption and renewable energy generated on site, such that energy requirements are met throughout the year [51]. Depending on the building classification and climate context, to achieve zero energy thinking, it is This is done through the following principles:

7. 1. Reduce the energy demand of all newly constructed buildings. The energy demand value is the sum of the requirements of the building, space heating and cooling, water heating, auxiliary power, ventilation, lighting, and appliances.

7. 2. Improving the indoor environmental quality (IEQ), allowing maximum thermal comfort, and avoiding overheating that includes monitoring air quality through mechanical ventilation.

7. 3. Determine a percentage of renewable energy demand that is covered by the annual renewable energy balance. Additional energy calculations are also important to address energy matching and storage issues.

7. 4. Reduce the comprehensive value of primary energy consumption and carbon emissions annually. It is also important to consider manufacturing energy transfer [16].

Table 1 - principles of zero energy buildings.

First principle	Second principle	Third principle	Fourth principle
Reducing energy demand	Improving the indoor environmental quality	Providing the share of renewable energy	Reducing primary energy and carbon emissions
Reducing internal loads	Calculate the minimum amount of fresh air per person	Producing energy from energy sources	Reducing primary energy demand
Reducing thermal loads on the outer shell	Enable natural lighting	Producing renewable energy on site that is used to transfer energy to the site from another place near the site.	Reducing carbon emissions resulting from or related to energy used.
Energy consumption of air conditioning equipment	Determine the maximum intensity for the user		
Energy efficiency inside the building	Maintaining indoor environmental quality	Improving building production from renewable energy sources	Reducing carbon dioxide emissions

8 .ELEMENTS OF THE STUDY OF ZERO-ENERGY BUILDINGS

The working method of zero-energy buildings lies in designing all the work components and integrating them transparently and perfectly within an integrated unit to work as a single system. There are many opinions about the basic components of zero-energy buildings, including:

8 .1 .Carbon Dioxide Emissions

Greenhouse gases are produced when fossil fuels are burned to produce energy, causing global warming. Zero-energy buildings contribute to reducing carbon dioxide emissions, in the short term, by reducing primary energy (the energy required to generate site-specific energy) until it reaches the site. End-use energy (is the amount of electricity used on the site). The European Union has proposed a maximum limit for CO2 emissions of 3 kg CO2/m2 per year. In the long term, carbon emissions resulting from the production of building materials are reduced, and therefore sustainable building materials with a long lifespan must be chosen. There are no specific standards for CO2 emissions from building materials, as rating systems such as Leed, Breeam, DGNB and others reward designers when taking into account emissions from green construction materials [17].

8. 2. Energy efficiency

European standards provide clear definitions of energy levels and the steps for calculating and measuring them. Evaluating the energy efficiency of new buildings and retrofits requires calculating energy needs for heating, cooling, and hot water and energy use for lighting and ventilation. As the EN15603 standard offers clear wording with a degree of flexibility for Member States the challenge of implementing and complying with NZEB performance requirements is high. The challenge is not only for new construction, but also for renewal A more precise definition of indicators [18] will help in the future to move towards a stronger framework for construction industry actors, without restricting the flexibility needed in each country. The NZEB must consume very low energy and emit less CO2 by design, rather than meeting increasing energy demand with on-site renewable energy generation [19].

8. 3. Thermal Balance

Characterizing the balance between heating and cooling energy needs is important for high-performance buildings to reduce unnecessary space conditioning and distribution systems. For example, in heating-dominated climates, designers seek to eliminate active cooling by using passive cooling design measures. This can lead to significant cost reductions due to the use of a single active mechanical system while providing simple control and maintenance.

Any definition of zero energy buildings must take into account the thermal balance of each climate zone in each region or country and requires the use of energy efficiency standards and the recommendation of efficient solutions and use of systems.

8. 4. Indoor Environmental Quality

Architecture is concerned with studying and designing the spatial environment in which humans live to protect them from external environmental factors. Architecture takes into account the size of the place, the proportions between its length and its organization, its mass, texture, function, and the social conditions surrounding it. It reflects the culture of the society, the nature of the regional climate, the surrounding area, and economic conditions. It is a combination of technical and design considerations. Indoor environmental quality (IEQ) refers to the extent to which people live efficiently and comfortably in indoor spaces as interpreted by the sum of their psychological and organic responses to architectural design factors. Short-term and long-term thermal comfort indicators must be calculated according to EN16798, in addition to energy performance indicators.

8. 5. Occupancy Density

Control and air conditioning technology has evolved, but it is important to put people first. It is important to always look beyond technology to work with autonomous IEQ requirements and strive to optimize the energy and health of buildings to achieve well-being, productivity, and satisfaction simultaneously.

Increasing the energy efficiency of zero-energy buildings depends mainly on determining occupancy densities during the design phase in accordance with occupancy densities during the building's operation [14].

8 .6 .Renewable Energy Production

Energy efficiency is an effective policy tool, in addition to providing energy in terms of cost, and also has a role in meeting energy needs, climate and economic goals. However, many new installations around the world fail to take effective renewable energy and energy efficiency measures. Investing in building renewable energy technologies appears easier to implement and communicate with occupiers, investors and the media. On the other hand, European recommendations for zero energy buildings advise including a share of renewable energy production on site including a share of renewable heat pumps. However, in dense urban areas, renewable energy sources (solar energy, imported biomass, etc.) have limitations on access to solar energy and pollution associated with burning biomass [20].

8 .7 .Total Cost

The cost of zero-energy buildings is calculated for three components: the initial cost, the operating cost for a long period of time of no less than 15 years, and the average life of the building for the same period of operation, which is called the global cost, it is one of the standards by which buildings are evaluated globally, and is calculated in euros/square meter. Legislation in European countries uses the Cost Optimal Approach, which is a study of all possibilities for using design processsings and modern technology appropriate to climatic conditions to reach the optimal approach to determining the cost of zero-energy buildings [21].

8 .8 .Design and construction System

They are determined according to codes specific to each region and are controlled by the previous elements, shaping them to suit the climate and economic situation, whether the interior or exterior design.

8 .9 .Behavior of Occupants

It remains one of the most important points to study the behavior of users and provide them with the required thermal comfort, but no matter how perfect the building is in its design, it does not become valuable without the building's occupants being aware of the importance of energy and how to conserve it. The behavior of the occupants can also be controlled by the controller found in smart homes [22].

9. A MODEL FOR DESIGNING A SUSTAINABLE ZERO-ENERGY BUILDING USING BUILDING INFORMATION MODELING

Through the previous presentation of the theoretical framework and relying on the best methods to achieve zero-energy architecture, the simulation model discusses the effect of building materials, thermal insulation, and type of glass on the thermal performance of the residential building in the hot, dry climate, especially in the Greater Cairo region, and a study of Sakan Masr units for workers' housing in the New Administrative Capital. This is done using computers and simulation programs. This part studies the effect of different building materials, thermal insulation, and types of glass on energy efficiency in residential buildings. (Sakan Masr units for workers' housing in the New Administrative Capital).

9. 1. Applied Study Methodology

- Analysis of climate data for the study area, "Greater Cairo Region".

- Analytical description of the chosen building.

- Usage data (architectural description, description of current building materials, occupancy rate).

- Evaluate the basic condition using simulation, for the existing residential building using the Design Builder simulation program and using the same current materials, then evaluate it.

- Compare and discuss the results. In this way, various design alternatives and material alternatives can be evaluated in order to choose the best solutions that contribute to achieving thermal comfort requirements and providing a good environment for users.

9. 2. Set up the Hypothesis

The use of thermal insulation, energy-saving glass, and the use of renewable solar energy improve energy consumption and achieve zero-energy buildings.

9. 3. Limitations of Simulation

This study was conducted using the Design Builder simulation tool, which is a suitable analysis tool through which a wide range of simulation and functional analysis can be provided, “where data is entered in an easy manner to create a model of the building to access accurate data and realistic simulation.”

- Simulation is done for the final floor.

- The climate data for the Greater Cairo region is taken into account when studying housing units for workers in the New Administrative Capital when performing the simulation. It is a hot, dry climate, and the study will be conducted in five steps:

First: Egypt’s housing units for workers’ housing in the New Administrative Capital are selected and a simulation of its heat gain is performed.

Second: Make an amendment to the model by adding thermal insulation to the ceilings and walls and the type of glass in the openings.

Third: Simulate the base case and calculate the cooling loads required for Egypt’s workers’ housing units in the New Administrative Capital.

Fourth: Make a comparison of these results to find out which one is better in thermal insulation, and which one has the highest value in the heat exchange coefficient U-Value.

9. 4. Analysis of the study area for the Greater Cairo region. Study of Sakan Masr units for workers’ housing in the New Administrative Capital.

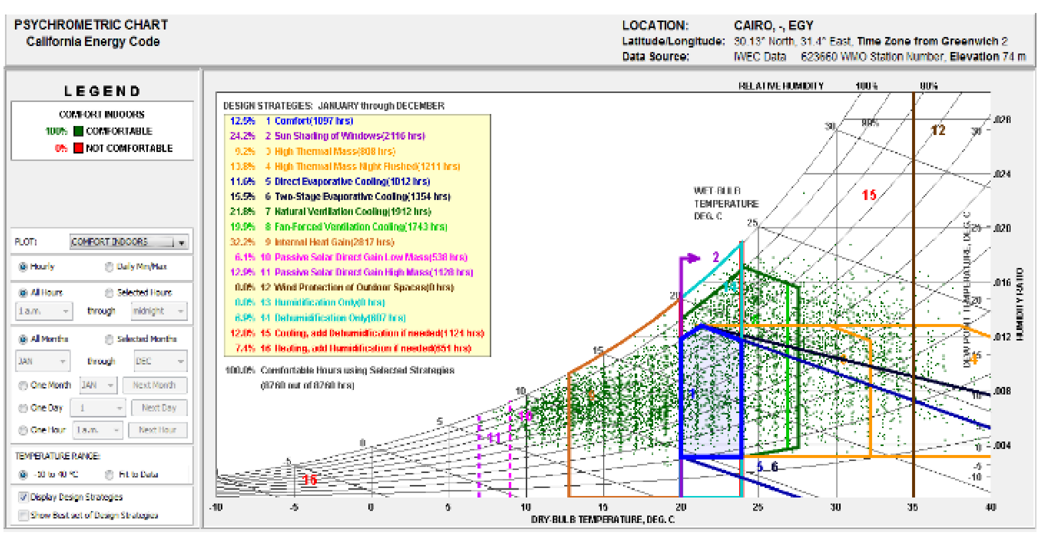


Figure 2. Psychometric map of the Greater Cairo region (Source: climate consultant 6.0)

9. 5. Analytical description of Sakan Masr units for workers' housing in the New Administrative Capital.

project name	**Sakan Masr units for workers' housing in the New Administrative Capital**
Illustration of the building	 **Figure (3):** Model of Sakan Masr units for workers' housing in the New Administrative Capital **Source:** New Urban Communities Authority website**.**
Type	Residential building - medium housing
General location	It is a model of Sakan Masr units for workers' housing in the New Administrative Capital □ Located in Badr City. □ The implementation of 376 buildings, with a total of 9,024 housing units for workers in the Administrative Capital, was completed at a cost of 3.2 billion pounds. The building consists of a ground floor and 5 recurring floors, and each floor includes 4 units, with a total of 24 housing units in each building. □ The unit consists of 3 rooms and a hall, fully finished and services, with a total area of 118 square meters. This aims to provide an integrated life for the employees of the Administrative Capital within the city. □ **Figure (4): General location model of Sakan Masr units for workers' housing in the New Administrative Capital** Source: New Urban Communities Authority.  https://www.google.com/maps/d/u/0/viewer?mid=1kjcRVADpTrhS5RYd4fK0I6hkFyhBn1I&hl=en_US&ll=30.124540724257866%2C31.78532120656322&z=19 20-3-2024

9 .6 .Results

The results after applying the processing to the building showed a decrease in the energy level in the building in different directions (north - east - south - west), and through energy programs and data extraction, energy decreased in different percentages, as shown in the following table:

Horizontal plan

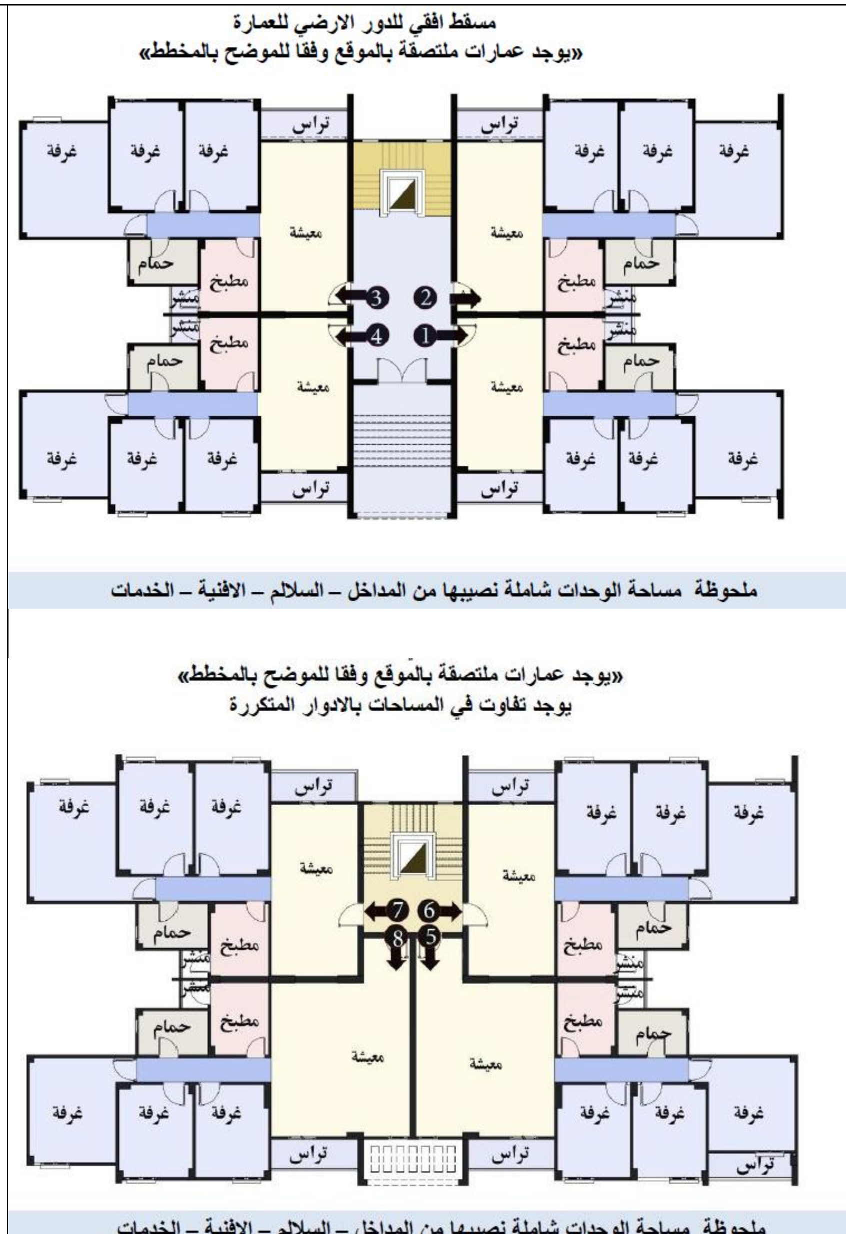


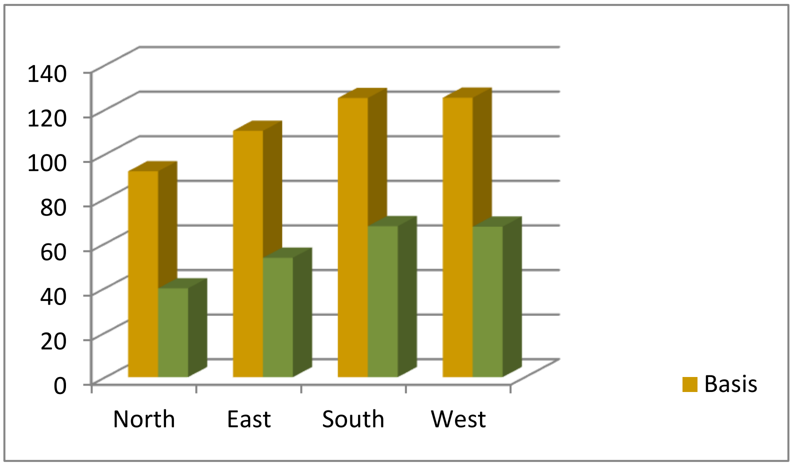
Figure (5): horizontal plan of Sakan Masr units for workers' housing in the New Administrative Capital
Source: New Urban Communities Authority.

9. 6. 1. Results of energy consumption according to different types of orientation for the model of housing units in Egypt, workers' housing in the New Administrative Capital.

Initial processing: adding 6 cm of thermal insulation to 25 cm thick walls, adding 8 cm of thermal insulation to the ceiling and 6 mm single glass.

Orientation	Basis	Initial processing	Savings	Rest
North	92.32	39.82	57%	43%
East	110.48	53.54	52%	48%
South	125.19	67.71	46%	54%
West	125.31	67.5	47%	53%

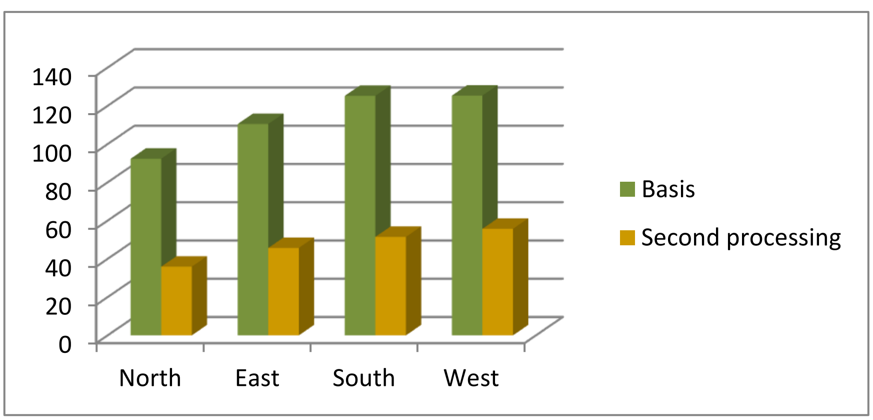
Table (1) the energy reduction results for the model of Sakan Masr units for workers' housing in the New Administrative Capital, in the case of a wall thickness of 25 cm, red bricks, thermal insulation thickness of 6 for the walls, thermal insulation thickness for the ceiling of 8 cm, and 6 mm single transparent glass.



Second processing: adding 6cm thermal insulation for wall thickness 25cm with add 8cm thermal insulation for ceiling and 6mm double glass.

Orientation	Basis	Initial processing	Savings	Rest
North	92.32	35.9	61%	39%
East	110.48	45.69	59%	41%
South	125.19	51.48	59%	41%
West	125.31	55.7	56%	44%

Table (2) the energy reduction results for the model of Sakan Masr units for workers' housing in the New Administrative Capital, in the case of a wall thickness of 25 cm, red bricks, thermal insulation thickness of 6 for the walls, thermal insulation thickness for the ceiling of 8 cm, and double transparent glass of 6 mm.



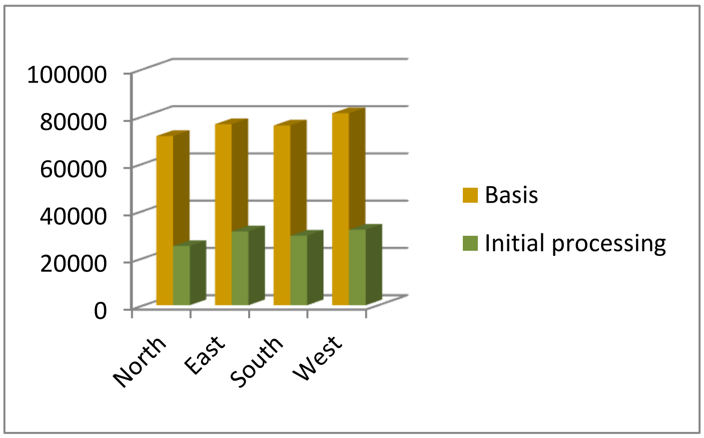
After applying the processing through energy programs and data extraction, the energy was reduced as shown in Table (1), (2) and the remaining energy consumed will be used renewable energy such as solar energy to bring the building to zero energy.

9. 6. 2. Results for carbon dioxide emissions for a model of Sakan Masr units for workers' housing in the New Administrative Capital.

Initial treatment: Adding 6 cm of thermal insulation to 25 cm thick walls, adding 8 cm of thermal insulation to the ceiling and 6 mm single glass.

Orientation	Basis	Initial processing
North	71609.52	25050.2
East	76610.37	31267.4
South	76064.36	29443.21
West	81254.92	31954.38

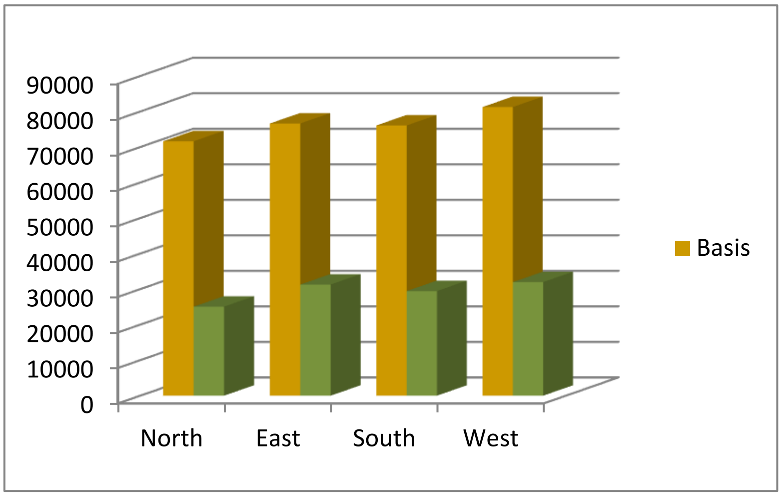
Table (3) the results of the reduction in carbon dioxide for a model of Sakan Masr units for workers' housing in the New Administrative Capital in the case of a wall thickness of 25 cm, red brick, thermal insulation thickness of 6 for the walls, thermal insulation thickness for the ceiling of 8 cm, and single 6 mm transparent glass.



Second processing: Adding 6 cm of thermal insulation to the 25 cm thick walls, adding 8 cm of thermal insulation to the ceiling and 6 mm double glass.

Orientation	Basis	Second processing
North	71609.52	24231.65
East	76610.37	28542.63
South	76064.36	27434.95
West	81254.92	29266.91

Table (4) the results of the reduction in carbon dioxide emission for Sakan Masr units for workers' housing in the New Administrative Capital in the case of a wall thickness of 25 cm, red brick, thermal insulation thickness of 6 for the walls, thermal insulation thickness for the roof of 8 cm, and double transparent glass of 6 mm.



After applying processing through energy and data extraction programs, the percentage of carbon dioxide emission was reduced, as shown in Tables (3) and (4).

CONCLUSIONS

The BIM model is an imaginary model of the building to be constructed that contains all the architectural and structural elements, and all the necessary electrical and mechanical systems to operate the building. All these systems modify themselves and recalculate their components in the event of any modification in the architectural design itself. The BIM model also tests all existing systems in the building, detecting any overlap or conflict between them and resolving them, which avoids many implementation problems on site. Building information modeling contributes to achieving sustainability standards, as with the rising cost of energy and increasing environmental concerns, the use of sustainability principles in the field of design and providing a minimum environmental impact is increasing, and therefore more effective sustainability decisions are made in the building's components at the early design and pre-implementation stages. From this standpoint, BIM can assist in complex building performance analyses to ensure a sustainable building design.

Zero energy principles provide a distinct approach to achieving sustainability as they reduce the use of resources, maximize their benefit, and reduce the amount of pollution resulting. Zero energy seeks to produce architecture that is compatible with the environment, while reducing its negative impacts, achieving maximum energy efficiency, in addition to the possibility of benefiting from renewable energy sources, and reducing operating and maintenance costs.

Recommendations for further research and development in the field of zero-energy sustainable building design using BIM technology include:

1. Directing investors to provide renewable energy means such as solar energy cells, as they are an element that society needs in the coming period.

2. Providing green design elements and conducting energy measurements on the building for a full year to cover all its energy needs through renewable energy means, so that it becomes a zero-energy building.

3. The concepts of zero-energy architecture represent one of the sources of thought related to sustainability issues, which architects should adopt in their buildings, as they are the least harmful to the environment.

4. The world is facing a major energy crisis; Especially with the energy sector relying mainly on fuel sources, which have severe impacts on the environmental threat.

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