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Research paper

The use of BIM to propose alternative construction methods to reduce the cost of energy for the historic archeological building in Iraq

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Abstract: The building information modeling (BIM) method is one of the newest methods that has been widely used in many parts of the building business, including energy management. The aim of this research is to analyze the most holy theotokos in order to find the best set of modifications that result in an optimal energy cost. The analysis was conducted through the use of building information modeling (BIM) technology and the associated programmers such as Auto Desk Revit 2020 and Auto Desk Insight 360, in order to determine the optimal strategies by which the most applicable alternative construction materials and procedures are considered in order to obtain an environmentally and economically sustainable most holy theotokos. Applying this analyze to the most holy theotokos revealed that many alternatives are capable of making a tangible reduction in the cost of electrical energy consumption and the cost of fuel for generators. Such reductions are noticed when altering in the optimum manner. The alteration of construction materials for walls and roofs also reduces the cost of electrical energy consumption and fuel for generators. The results show that changing the plug load efficiency in the optimal manner reduces the cost of electrical energy consumption by approximately 933913 US dollar ($), and changing the heating, ventilating, and air conditioning systems (HVAC) reduces the cost of fuel energy consumption by approximately 13522 US Dollar ($). Green building studio (GBS) is a tool that helps in the early stages of a project to find the best ways to save energy.

Keywords: autodesk insight 360 cloud, BIM, construction project, energy efficiency, historic archeological building, sustainable design parameters

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1. Introduction

Due to the important role played by the energy sector and due to the economic crisis that the country is experiencing, the idea of research is to study the possibility of using environmentally friendly alternatives in old buildings, including religious shrines, in order to reduce the cost of electrical energy consumption and fuel for generators consumed by these shrines. The most important factor influencing electricity and fuel consumption. The BIM capability will be used to visualize the buildings in 3D in order to create and update schemes that are based on reality. This will replace any schemes that are either missing or unclear.

Both organizational innovation that is connected to the building information modeling (BIM) concept and sustainability are two important trends of global changes within the construction industry that have been observed and described in numerous publications over the course of the past few years. These trends have been observed and described in numerous publications. Those changes happened in isolation and were not influenced by one another.

In addition to using Rivet 2020 and Autodesk Insight 360 cloud to evaluate several sustainable design solutions, the researcher also explains the integration approach of the BIM model in this study. Discussion the ramifications of these discoveries are then discussed by the researcher. Using Autodesk green building studio (GBS) to conduct an examination of a structure by coming up with design ideas and analyzing the building's energy performance.

2. Literature review

One of the most important economic sectors, construction, significantly boosts the gross domestic product of most countries. It is the stage of civil engineering when the planner's thoughts and the designer's specific plans come to fruition [1]. The word "construction project" refers to a particular high-value, time-constrained mission with specified performance goals. In challenging project circumstances, the project's goal is achieved [2]. Because it is not frequently subject to regulated taxonomy circumstances, the building project is regarded as being distinct from the rest of the standard production processes [3]. The term sustainability is also known by various names, including green building, ecologically friendly structures, sustainable design, sustainable cities, and sustainable development. The last phrase, which encompasses the previous words in a broader sense [4]. Sustainability refers to the development of designs that aim to strike a balance between the immediate objectives of a project and the long-term objectives of effective operating systems that preserve the environment and natural resources. Sustainable building is an all-encompassing method of construction that utilizes the benefits of contemporary technology and tried-and-true construction techniques, allowing nature to work with the structure's efficiency rather than against its [5]. A systematic implementation of sustainable techniques in the design and construction sectors of the building industry is known as sustainable construction [6]. The phrase "sustainable construction" refers to building practices that balance social, environmental, and economic performance by minimizing negative consequences while maximizing positive benefits [7]. From planning through disposal, the principles of sustainable building are applicable to the whole construction life cycle [8]. Throughout the lifespan of infrastructure and other facilities, the main goal of sustainable building is to limit the depletion of water, energy, and raw material resources as well as the environmental damage caused by construction operations [9]. In addition to the building itself, the land where it will be placed must also be designed and built according to green standards [10]. Utilizing resources that are recyclable, reused, and renewable is a key component of sustainable building [5]. The thermal resistance of a building's envelope has a direct correlation to the amount of energy that a structure saves on its energy bill. In the context of fluctuating prices for energy, taking the price into consideration while evaluating the ideal thermal resistance of building envelopes is important. In the context of fluctuating prices for energy, it is particularly significant to take the price into consideration when establishing the best thermal qualities of the building envelopes of a structure [11]. BIM is an innovative approach to sustainable design that uses a number of techniques, such as lowering energy use and carbon emissions, to create a building that is ecologically friendly [12, 13]. Building information modeling (BIM) is a method for managing and planning buildings that uses a database to produce a virtual model with comprehensive data that is utilized throughout the building life cycle [14]. Structure information modeling (BIM) is the digital depiction of a real building or institution. The process of developing, using, and maintaining project data using a set of tools that can represent project data in a 3D format is known as BIM [15]. Building information modeling (BIM) has established itself as a crucial process facilitator for contemporary architecture, engineering, and building [8]. BIM is a sophisticated procedure made up of a number of virtual elements, systems, and ideas that are supported by a single environment [16]. The use of BIM technology not only enables the early resolution of any issues with energy efficiency that may arise during the early stages of a project's design but also contributes to the enhancement of energy efficiency in a variety of ways [17]. The potential for BIM integration into the life cycle of building projects is enormous [18]. The top three problems were that the government wasn't doing enough, people didn't want to change, and people didn't know about the benefits of BIM [19]. The goal of the building information modeling (BIM) technology is to facilitate the creation of a digital model of a building that, in addition to graphics, will include the building's physical and functional properties, as well as the parametric rules and relationships between the building elements. In addition, the model is applicable throughout the entirety of the building lifecycle, beginning with the design and continuing through construction, usage, and finally demolition [20]. The development of high performance buildings that integrate and optimise energy efficiency and life cycle performance is directly related to the need for a reliable assessment; shifting the focus to the reduction of building operational energy makes embodied energy a significant part of a building's life cycle [21]. According to its definition, historic building information modeling (HBIM) is a collection of parametric objects based on historical architectural information. Because it automatically generates complete engineering drawings for the conservation of historic structures and settings, including 3D documentation, orthographic projections, sections, details, and schedules, the HBIM is crucial to completing historical building conservation [22]. The facility is being modernised, revitalised, operated, and even visualised with the use of heritage or historic building information modelling (HBIM) technology, which allows for the construction of 3D models of objects [23]. The process of modelling advanced buildings, especially ancient objects, in three dimensions is a very laborious and time-consuming endeavor. The architectural aspects themselves frequently contribute to the intricacy of this style of object representation. Frequently, each component represents a unique kind of architectural style. In addition to the walls, there are apertures, asymmetrical roofs, balconies, cornices, pediments, pillars, vaults, domes, and features that were hand carved [24].

2.1. Advantages of energy efficiency

There are many benefits to energy efficiency [25]:

1. Energy modeling of the building at the design stage and depends on computer programs to represent all electrical loads (lighting, cooling, heating devices, etc.) and working on modifying the model to reach the optimal design.
2. The passive design of the structure by determining the path of the sun to take advantage of natural lighting and studying the speed and direction of the wind during the year to direct the building to achieve natural ventilation in order to reduce the consumption of electrical energy for lighting, heating and air conditioning.
3. Using the computational fluid dynamics technique to distribute the air inside the room well and to find an ideal distribution of air conditioning or heating vents, this leads to a reduction in electrical energy consumption.
4. Reducing the energy consumption of air-conditioning and heating devices by choosing high-efficiency devices, that is, those that have a higher performance factor.
5. Careful selection of the location of windows and good insulation of walls and ceilings to maintain the air temperature inside the room and prevent heat transfer between outside and inside the room.
6. The use of light-colored and reflective paints for walls and ceilings, which reduces the absorption of sunlight.
7. Reliance of the air conditioning pipes and the correct placement of moisture and air insulators.
8. Using renewable energy, for example wind, solar energy, or geothermal energy to meet energy needs, which greatly reduces the carbon emissions of these buildings.
9. Using IOT (integrated internet of things) systems that automate the systems that are provided to the building by keeping the values entered for the systems (air conditioning, for example) in addition to knowing the energy consumption in order to adjust our consumption as needed only.
10. Using environmentally friendly refrigerants for air-conditioning devices to increase the efficiency of these devices and most importantly also to reduce global warming and protect the ozone layer.

3. Research methodology

The research approach primarily consists of two elements, which are based on earlier studies connected to BIM technology and taking into account various strategies to accomplish energy management of the building.

3.1. Part one (theoretical study)

A review of the literature is done for earlier works that are relevant to the area of study, including theses, books, journals, and websites. A group of previous studies were relied on in theory as shown in Table 1.

Table 1. Represents a group of previous studies that were relied on in the theoretical aspect

Research	Country	The study
Tsilimantou & Delegos 2020	Greece	In this study ICT environments and more specifically GIS and BIM were utilized as integrated towards the structural assessment of a historic building
Vacca & Quaqureo 2020	Italy	This paper shows the findings of an ongoing research which is aimed at structuring the cognitive process and assessing enhancement and re-functionalization scenarios of our historical and architectural heritage through the use and integration of information systems such as BIM and the GIS
Zhang 2020	China	In this paper a heritage building information model (HBIM) is constructed through multi-dimensional data of cultural heritage buildings such as literature data, picture data and 3D scanning and through point cloud data processing and Revit software.
Pepe & Costantino & Garofalo 2020	Italy	The aim of this work is to identify an efficient pipeline in order to build accurate 3D models it is first necessary to perform a geometrics survey.

3.2. Part two (practical study)

This study in which the practical part includes the following (sustainable design options are evaluated by analyzing the building in Autodesk insight 360 Cloud, which is added to Revit 2020. The energy auditing that is included in this analysis is performed in accordance with ASHRAE 90.1. This analysis is carried out in the manner described below):

1. In Autodesk Revit 2020, create 3D building information model of the project.
2. Make sure each of the rooms has enough space.
3. Alter the energy setting and input some information, such as where the project will be located and what kind of project it will be.

4. In Rivet 2020, make an energy model and choose the optimization panel to use Insight 360 for an energy analysis in the cloud.
5. An examination of the energy used, with the results shown in the cloud using Autodesk Insight 360.
6. The results of the study tell us about the many parts of different design options and how those options affect the amount of energy used (EUI).
7. Show and compare different ways to improve energy efficiency through sustainable design by using the cloud version of Autodesk Insight 360.

The findings of the investigation were based on the Net-zero scenarios, which made the following points clear.

4. Case study

Most holy theotokos It is located in the Najaf governorate. It consists of an almost square courtyard that surrounds the upper sanctuary on its three sides: the northern, eastern, and southern; and on the western side. The Al-Haydari courtyard has a square footage of around 6878 m^2, and on its western side, it was shaded by a tall shed with a huge semi-circular arch in the center that was partially filled by a door leading to the hallway. Al-Rawdah Al-Haidari, also known as Al-Hadara, is the name of the top sanctuary, and it is situated about in the center of the courtyard. The structure, which surrounds the spotless shrine of the commander of the faithful, peace be upon him, is square in shape, is 176.89 square meters in area, and has walls that are around 12.5 meters high. The sacred shrine is surrounded on all four sides by four huge arches, or big high bowls, which are held up by four pillars that are surrounded by four large domes that sit above the sanctuary. Fig. 1 represents the most holy theotokos.

Fig. 1. Case study the most holy theotokos

4.1. Creating the 3D visualization for the case study

Visualization is a method that is employed to the advantage of the customer in order to obtain an understanding of the construction projects, and this is something that can be easily done when utilizing BIM. The conventional procedures include the production of drawings in only two dimensions, which the customers may find difficult to understand since it is impossible to form an accurate mental image of the complex projects based solely on the drawings. The researcher was able to make a visual representation of two different case studies with the help of Autodesk Revit 2020. The case study was rendering as shown in Fig. 2.

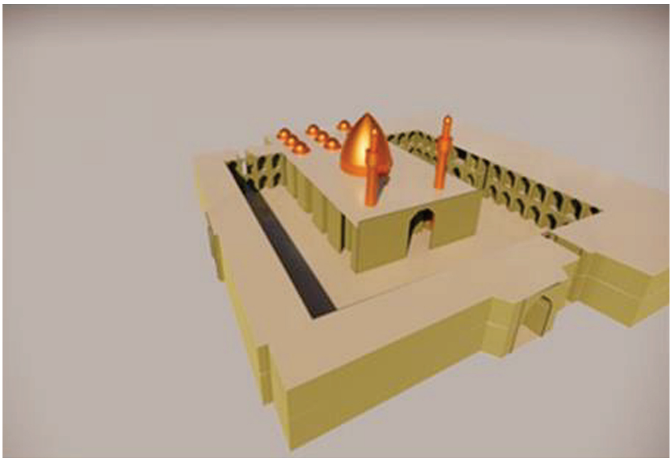

Fig. 2. Rendering of case study in Revit 2020

5. Findings and discussion

Results of this analysis are based on the energy settings, in Revit 2020 as well as the selected scenario in the web of Autodesk Insight 360. Figure shows the model of case study in the Insight 360 cloud, Results illustrated the following.

5.1. The orientation of the building

Building orientation is taken into account during the design process. Where BIM in this analysis is a function of the modeled value, it has a significant influence on lowering energy consumption, enhancing natural ventilation, and improving the indoor daylight performance of the building. Analysis in Insight 360 makes it possible to find the best way to position a building to reduce energy use, electric prices, fuel costs, and energy costs. Fig. 3 and Table 2. Show the 0° degree's orientation has fewer costs (electric, fuel, energy) than other orientations.

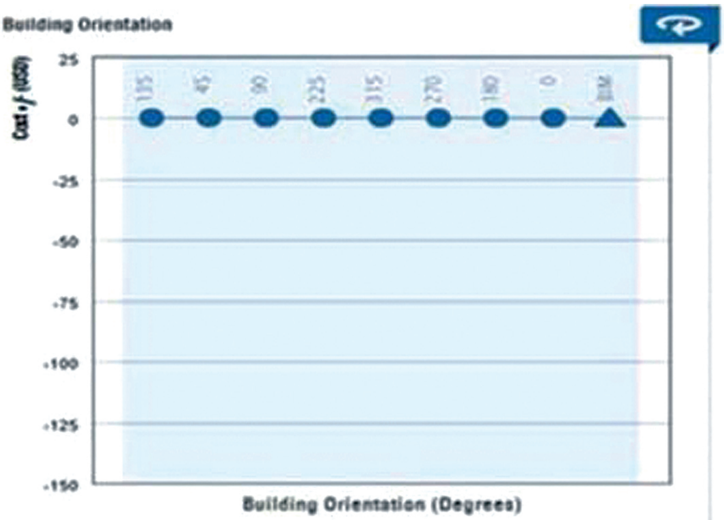

Fig. 3. Building orientation cost

Table 2. Building orientation types (electric, fuel) annual costs

Building orientation (Degree)	Electric ($)	Fuel ($)
0°	1411090	22641
45°	1411510	23091
90°	1411229	23283
135°	1411246	23356
180°	1411094	23002
225°	1411450	22981
270°	1411550	22842
315°	1411610	2279

5.2. Wall construction

This term refers to a wall's total capacity to withstand heat gains and losses. Wall type is taken into account while designing a structure since it significantly lowers energy usage. Insulating walls is important because it increases their thermal resistance, which has a big effect on how much energy they use. Fig. 4 and Table 3. Show R38 wood wall construction has fewer costs of (electric, fuel, and energy) than other types of sustainable walls for building.

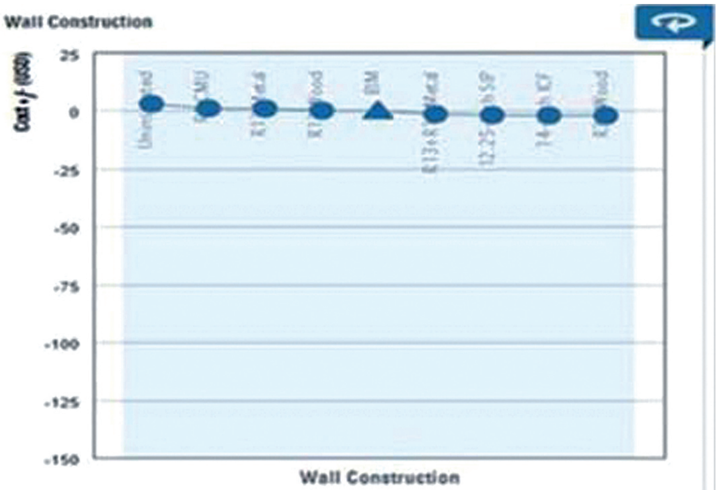

Fig. 4. Wall construction

Table 3. Wall construction types (electric, fuel) annual costs

Wall construction	Electric ($)	Fuel ($)
uninsulated	1424068	30201
R13 metal	1414844	2564
R13 wood	1411779	22676
R13+R10 metal	1403584	20137
14-inch ICF	1401980	17828
R38 wood	1401978	17012
R2 CMU	1414091	27164
12.25 inch SIP	1403325	17393

5.3. Plug load efficiency

The electricity that is consumed by equipment, such as computers and other small appliances; does not include lights or equipment used for heating and cooling. This analysis shows the various types of plug load efficiency that are used by equipment such as computers and small appliances. However, it does not include lighting or heating and cooling equipment. It also shows the extent to which these different types of plug-load efficiency have an impact on the intensity with which energy is used. Fig 5 and Table 4. Show plug load efficiency – 0.6 W/sf has fewer costs (electric, fuel, energy) than other types of plug load efficiency for the building.

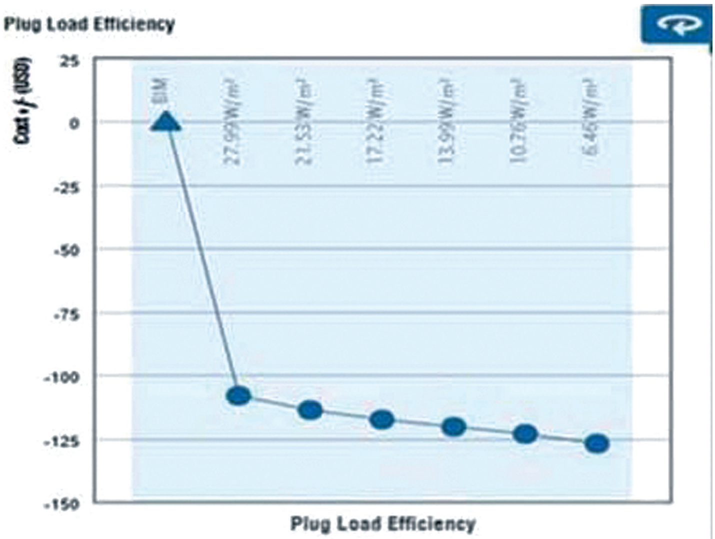

Fig. 5. Plug load efficiency

Table 4. Plug load efficiency (electric, fuel) annual costs

Plug load efficiency	Electric ($)	Fuel ($)
0.6 W/sf	536930	21982
1.0 W/sf	563265	22291
1.3 W/sf	582896	22181
1.8 W/sf	602540	22143
2.0 W/sf	628346	22130
2.6 W/sf	667421	21989

5.4. Heating, ventilation, and air-conditioned (HVAC) system

This is a range of possible efficiencies for the HVAC system, which will vary depending on the location and the size of the building. The heating, ventilation, and air conditioning (HVAC) system is one of the primary contributors to overall energy consumption. This system also has an impact on the interior air quality and air temperature of the structure. Fig. 6 and Table 5. Show that the ashrae package terminal heat P system has lower costs (electric, fuel, and energy) than other types of building HVAC systems.

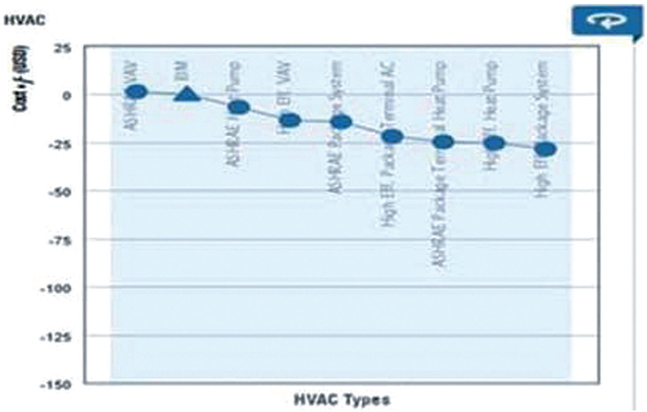

Fig. 6. HVAC

Table 5. HVAC types (electric, fuel) annual costs

HVAC	Electric ($)	Fuel ($)
Types ashrae package system	1320470	14739
High eff. heat pump	1249320	9790
Ashrae heat pump	1376543	11014
HIGH eff. package system	1224720	9177
Ashrae VAV	1422282	20937
High eff. VAV	1317630	23082
Ashrae package terminal heat P	1252926	11014
High eff. package terminal AC	1267058	16521

5.5. Energy operating schedule

The regular hours of operation for the building by its inhabitants are this research demonstrates the many operational schedules that may be used in buildings, as well as the extent to which these schedules can affect energy consumption and energy usage intensity. Fig. 7 and Table 6. Show the operating schedule (12/5) has fewer costs (electric, fuel, energy) than other types of operating schedule systems for the building.

Table 6. Operating schedule types (electric, fuel) annual costs

Operating schedule	Electric ($)	Fuel ($)
24/7	935328	41008
12/7	818793	30587
12/6	782852	29229
12/5	697033	22625

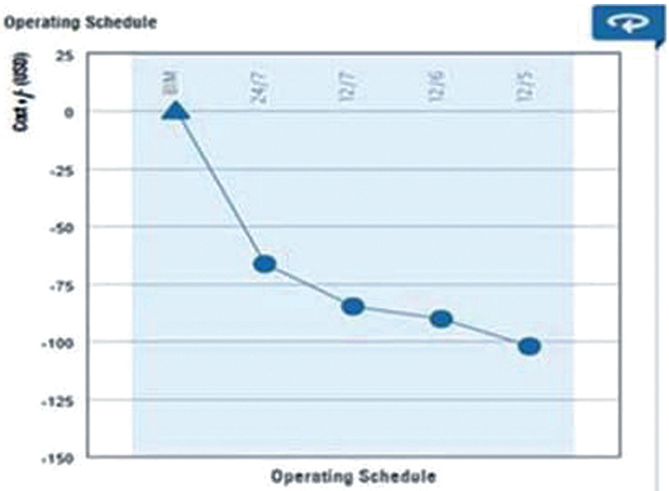

Fig. 7. Operating schedule

6. Energy simulation

Following the completion of the 3D BIM model in Revit 2020, the model will be exported to green building studio (GBS) through the use of the gbXML language. This will allow for the creation of design alternatives as well as data regarding energy usage and water efficiency. The green building XML template, also called gbXML, is an open schema that was made to make it easier for engineering analysis tools to use building information models (BIM) to access building data. Immediately following the conclusion of the file's export. It is saved, and then from the website of Autodesk green building studio (GBS cloud), the file is imported for energy simulation. Prior to beginning the process of energy simulation, you are required to enter some information, such as the name of the project, the type of project, and the operating schedule. If the project is an actual one, the location must also be entered.

7. Create design alternatives

The green building studio (GBS) enables the production of design alternatives that can improve the energy performance of the building. The design alternatives tab is where the alternative is placed once it has been created so that design parameters can be generated for it. In the same method, many different options, such as orientation, window ratio, window shades, HVAC system lighting control, window glass type, and wall type, which are provided by GBS, are taken based on an analysis by Autodesk insight 360 and define their impact on the amount of energy used and the amount of carbon emissions produced by the case study.

The annual energy saving will be calculated according to Eq. (7.1), Eq. (7.2):

(7.1) Annual electric fuel saving ($/year)
= annual electric cost of building – annual electric cost of alternative (Researcher)

(7.2) Annual energy fuel saving ($/year)
= annual fuel cost of the building – annual fuel cost of alternative (Researcher)

For the current annual electric cost was (1470843)$ and the current annual fuel cost was (22699)$. The Annual electric cost saving and annual fuel cost saving shown in Table 7.

Table 7. Illustrates that for, the annual electric cost saving and annual fuel cost saving

Alternative type	Alternative name	Annual electric cost of alternative ($)	Annual electric cost saving ($)	Annual fuel of alternative ($)	Annual fuel cost saving ($)	Annual energy cost saving ($)
(1)	(2)	(3)	(4)	(5)	(6)	(4) + (6)
Building orientation	0°	1411090	59753	22641	58	59,811
Wall construction	R38 wood	1401978	68,865	17012	5687	74,552
Plug load efficiency	Plug load efficiency – 0.6 W/sf	536930	933913	21982	717	934,630
HVAC types	HIGH eff. package system	1224720	246123	9177	13522	259,645
Operating schedule	Operating schedule – 12/5	697033	773810	22625	74	773,884

8. Conclusions

This article provided a description of the process that was used to construct a set of evaluation uncover appropriate tools and techniques that may assist in the management of energy by utilizing contemporary methodology. Based on the findings, the authors came to the following conclusions:

1. BIM is a highly helpful tool for doing a variety of analyses, each of which helps to uncover new solutions for enhancing the project's energy efficiency.
2. For annual electric cost saving, proposal alternatives are plug load efficiency has the highest electric cost saving (933,913)$ and building orientation has the lowest electric cost saving (59,753)$.

3. For annual energy cost saving, proposal alternatives are plug load efficiency has the highest energy cost saving (934,630)$ and building orientation has the lowest energy cost saving (59,811)$.
4. The findings demonstrate that there is a straightforward distinction between the estimated consumption of electric and fuel energy and the actual consumption of electric and fuel energy. This finding suggests that the utilization of BIM is very useful for evaluating energy performance during the design stage.

References

[1] Y.A. Ali, "Building an expert system for consultants and contractors performance in overpasses projects", M.A. thesis, University of Technology, Building and Construction Engineering Department, Iraqi, 2018.

[2] L.C.K. Chitkara, *Construction project management: planning, scheduling and controlling*. Tata Mc Graw-Hill Education, 2010.

[3] A. Walker, *Project management in construction*. John Wiley & Sons, 2015.

[4] M.H. Yahya, "Cost optimization during design stage in projects of school buildings using value engineering", M.A. thesis, University of Technology, Building and Construction Engineering Department, Iraqi, 2018.

[5] S.M. Levy, *Project management in construction*. Mc Graw-Hill Education, 2018.

[6] M.M. Darwish, M.F. Agnello, and R. Burgess, "Incorporating sustainable development and environmental ethics into construction engineering education", in 8^{th} *Latin American and Caribbean Conference for Engineering and Technology (LACCEI, 2010)*. Lubbock, Texas, USA, 2010, pp. 2–5.

[7] H. Zabihi, F. Habib, and L. Mirsacedie, "Sustainability in building and construction: revising definitions and concepts", *International Journal of Sciences*, vol. 2, no. 4, pp. 570–578, 2012.

[8] J.C. Kibert, *Sustainable construction*. John Wiley & Sons, 2013.

[9] M. Wahlstrom, et al., *Environmentally sustainable construction products and materials – assessment of release and emissions*. Nordic Innovation Publication, 2014, pp. 17.

[10] E.J. Anderson, et al., *Sustainable structural engineering*. International Association for Bridge and Structural Engineering, 2015.

[11] X. Wu and Y.Y. Zhi, "Study on daylighting mode of energy-efficient buildings", *Polityka Energetyczna-Energy Policy Journal*, vol. 24, no.2, pp. 183–206, 2021, doi: 10.33223/epj/136076.

[12] R.L. Peurifoy, et al., *Construction planning, equipment and methods*. Mc Graw-Hill Education, 2018.

[13] S. Mordue and R. Finch, *BIM for Construction Health and Safety*. Published by Riba Publishing, 2014.

[14] F.F. Taha, "Achieving net-zero energy in educational buildings using BIM", M.A. thesis, University of Diyala, Collage of Engineering, Iraqi, 2020.

[15] C.J. Schexnayder and C.M. Fiori, *Handbook for building construction: administration, materials, design, and safety*. Mc Graw-Hill Education, 2021.

[16] S. Azhar, M. Khalfan, and T. Maqsood, "Building information modelling (BIM): now and beyond", *Construction Economics and Building*, vol. 12, no. 4, pp. 15–28, 2015, doi: 10.5130/AJCEB.v12i4.3032.

[17] F.F. Taha, W.A. Hatem, and N.A. Jasim, "Effectivity of BIM technology in using green energy strategies for construction projects", *Asian Journal of Civil Engineering*, vol. 21, no. 6, pp. 995–1003, 2020, doi: 10.1007/s42107-020-00256-w.

[18] L. Chen and H. Qu, "Evaluation for economics and legislative factors influence the design team and contractor throughout a building project from inception to completion", *Journal of System and Management Sciences*, vol. 1, no. 6, pp. 94–108, 2011.

[19] H.R. Abed, W.A. Hatem, and N.A. Jasim, "Role of BIM technology in enhancing safety analysis of Iraqi oil projects", *Asian Journal of Civil Engineering*, vol. 21, no. 4, pp. 695–706, 2020, doi: 10.1007/s42107-020-00231-5.

[20] S. Biel, "Concept of using the BIM technology to support the defect management process", *Archives of Civil Engineering*, vol. 67, no. 2, pp. 209–229, 2021, doi: 10.24425/ace.2021.137164.

[21] W. Celadyn, "An investigation of the potential of dematerialization to reduce the life cycle embodied energy of buildings", *Archives of Civil Engineering*, vol. 67, no. 4, pp. 59–77, 2021, doi: 10.24425/ace.2021.138486.

[22] L.M. Kodeir and A.A. Nessim, "BIM2BEM integrated approach: examining status of the adoption of building information modelling and building energy models in Egyption architectural firms", *Ain Shows Engineering Journal*, vol. 9, no. 4, pp. 1781–1790, 2018, doi: 10.1016/j.asej.2017.01.004.

[23] A.S. Graczyk, Z. Walczak, B. Ksit, and Z. Szyguła, "Multi-criteria diagnostics of historic buildings with the use of 3D laser scanning (a case study)", *Bulletin of the Polish Academy of Sciences: Technical Sciences*, vol. 70, no. 2, 2022, doi: 10.24425/bpasts.2022.140373.

[24] I. Piech, T. Adam, and P. Dudas, "3D modelling with the use of photogrammetric methods", *Archives of Civil Engineering*, vol. 68, no. 3, pp. 481–500, 2022, doi: 10.24425/ace.2022.141898.

[25] R.D. Woodson, *Be a successful green builder*. Mc Graw-Hill Education, 2009.

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