



## Building Energy Management using BIM Technique: Iraq Construction Projects as A Case Study

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### ABSTRACT

Building Information Modeling (BIM) technique is one of the modern techniques that have become widely used in many areas of the construction sector, including energy management. This work aims to study the effect of sun path analysis in improving energy performance, analysis and evaluation of the energy performance based on the tools provided by BIM technique, and comparison of simulated electrical energy results with real electrical energy consumption. The criteria of this study applied on one Iraqi project at Diyala University. The results illustrate that BIM very useful to perform various analyses helped to find different strategies for improving the energy efficiency of the project such as sun path analysis and Green Building studio (GBS) tool based on BIM technique useful tool to energy analysis where the result illustrate most electricity consumption goes for cooling space with consumption around (63871) kWh in August month as well as most fuel consumption for the purpose of space heating with consumption around(187846) MJ in December. GBS tool based on BIM technique is an effective tool that can help designers and architects in energy performance assessment as well as calculate energy costs in the early design stage, also it helps in finding the best solutions that contribute to improving energy efficiency in the early stages of the project life cycle.

## 1. Introduction

The construction sector consumes 40% of the total energy around the world, where most of this consumption goes to the purposes of cooling, heating, and ventilation. Therefore, improving energy efficiency is a major issue in the construction industry[1]. In recent years, the electric power in Iraq suffers from being insufficient for national demand[2]. Traditional CAD schemes environments typically do not have the ability to perform performance analyses in the early design stage where performance analyses typically performed after produced all architectural design and

construction documents[3,4]. Building Information Modeling(BIM) technique is one of the modern technologies that allow multidisciplinary information to overlap in one model, which creates an opportunity to perform sustainability measures and analyses energy performance in the early design stage[5]. BIM technology helps in increasing energy efficiency through many strategies and it also gives the capability to solve all problems related to energy efficiency in the early design stage of the project[6]. building components have the most effect on energy dissipation where energy dissipation of wall around 35%, roof around 25%, windows around 10% as and floor around

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15% [7]. evaluated time schedule for projects in various construction companies by adopting AHP technique [8].

In recent years, Iraq has suffered from many energy problems where electrical energy has become insufficient for national demand. the construction sector is one of the most contributors to energy consumption and environmental impact. Therefore, the authors in this study relied on BIM technique as it is one of the modern technologies that contribute

significantly to energy management. This study aims to the following:

1. Study the effect of sun path analysis to improve energy performance.
2. Analysis and evaluation the energy performance based on the tools provided by BIM technology.
3. Comparison of simulated electrical energy results with real electrical energy consumption.

### *1.1 Paper structure*

The structure of the paper is organized as the following: Section one shows the current introduction. Section two explains literature review, research methodology of this study, and illustrates the selected case study (Deanship Building of Agriculture Collage at Diyala University). Also, section two explains Sun Path Analysis in Autodesk Revit 2018. Section three discusses the result of this obtained by using BIM tools for energy analysis and evaluation then will compare simulated electrical energy results with real electrical energy consumption. Section four illustrates the conclusion of this study.

## **2. Literature review**

In Iraq, many researchers focused on using BIM technique to improve the various aspects of the construction sector. For example, Abd& Khamees, (2017) [9] studied the possibility of using BIM to address conflict detection during the project life cycle. The results illustrate the ability of BIM to detect the conflicts and to re-

document buildings. Hatem et al., (2018) [10] studied the obstacles that guide the adoption of BIM technique in Iraqi construction projects. The results of this study showed that there are many obstacles that guide the adoption of BIM technology in Iraq. The top three obstacles were weak efforts by the government, resistance to change, weak awareness and knowledge of BIM benefits. Abed et al., (2020) [11] studied the effect of the application of BIM technique in improving safety for Iraqi oil projects, as well as its impact on schedule time and costs. The results showed that the application of BIM technique helps in solving all safety problems in the early stages of the project life. Abd& Jarullah, (2018) [12] studied the effect of the lightweight foamed concrete brick as an alternative of clay bricks on cost and energy consumption by using BIM. The results illustrate the cost of lightweight foamed concrete brick is higher than normal clay brick as well as lightweight foamed concrete brick is lower energy consumption than normal clay brick.

Many researchers focused on the role of BIM technique in improving and energy evaluated. For example, Azhar et al., (2009) [13] investigated about benefits of sustainability analyzes based on BIM technique as well as the assessment of several building energy analysis tools. In this study, the results are expected to be useful to construction and architecture organizations that interested to use BIM for sustainable design. Shoubi et al, (2015) [14] evaluated a set of materials to find the best sustainable alternatives reduce operating energy consumption by using BIM technique. In the end, this study suggested some sustainable solutions to reduce energy consumption as well as the results of this study very useful for designers and architects to use BIM technique to develop energy-efficient buildings in the future with the aim of achieving sustainable development in the construction sector. Revit 2012 and Ecotect Analysis software were adopted in this study. Somboonwit & Sahachaisaeree, (2018) [15] studied the role of BIM in performing energy analysis and improving energy performance as well as

illustrates the effect of the building’s orientation on energy consumption. Naji et al., (2019)[16] studied the effective alternatives for roofs and walls to reducing electricity power. The results of this study illustrate the excellent ability to use BIM technique with AHP for selecting the best construction materials to reduce electricity consumption.

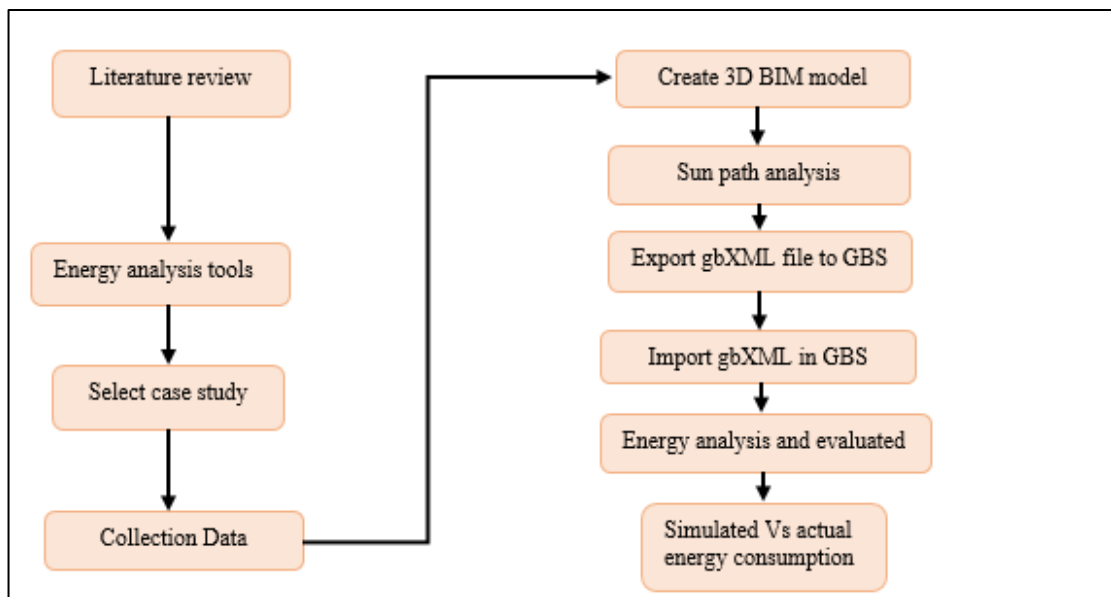
As explained above, many researchers in different countries are studying the role of BIM technique in improving and energy evaluated by using different tools but the role of the GBS tool has not been addressed in energy performance evaluated.

### 3. Research methodology

On considering different methods from the previous studies related to BIM, energy management of the building, the research framework is developed as shown in

Figure (1). This research methodology is organized as follows:

1. The case study is selected and data collection from professional engineering which includes (CAD drawings, schedule of quantities) as well as take realistic pictures of case study as shown in figure(2a).
2. Create 3D model by using Autodesk Revit 2018 software as shown in figure (2b).
3. Export 3D BIM model to Autodesk Green Building Studio (GBS) by using gbXML format to energy performance analysis as shown in figure (3).
4. Import gbXML in GBS where figure(4) shows 3D VRML model in GBS
5. Evaluate energy performances of project.
6. Finally, discussion the conclusions and recommendations reached by the researcher.



**Fig. 1** Research methodology framework

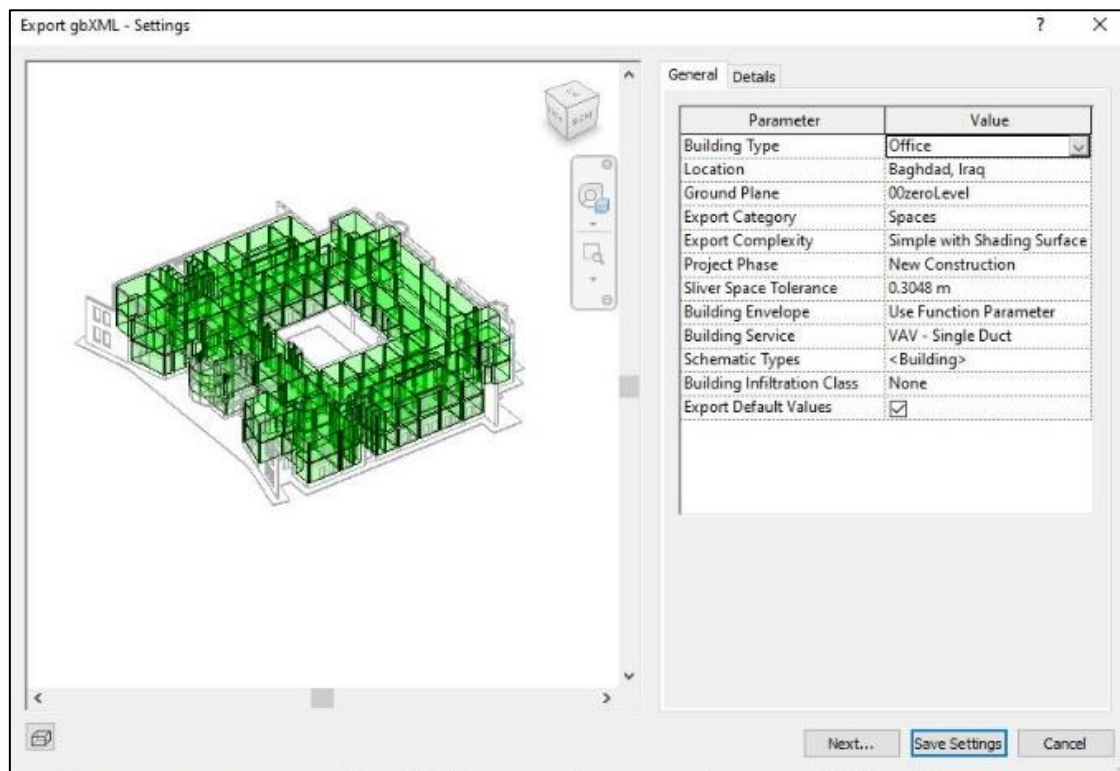


(a)

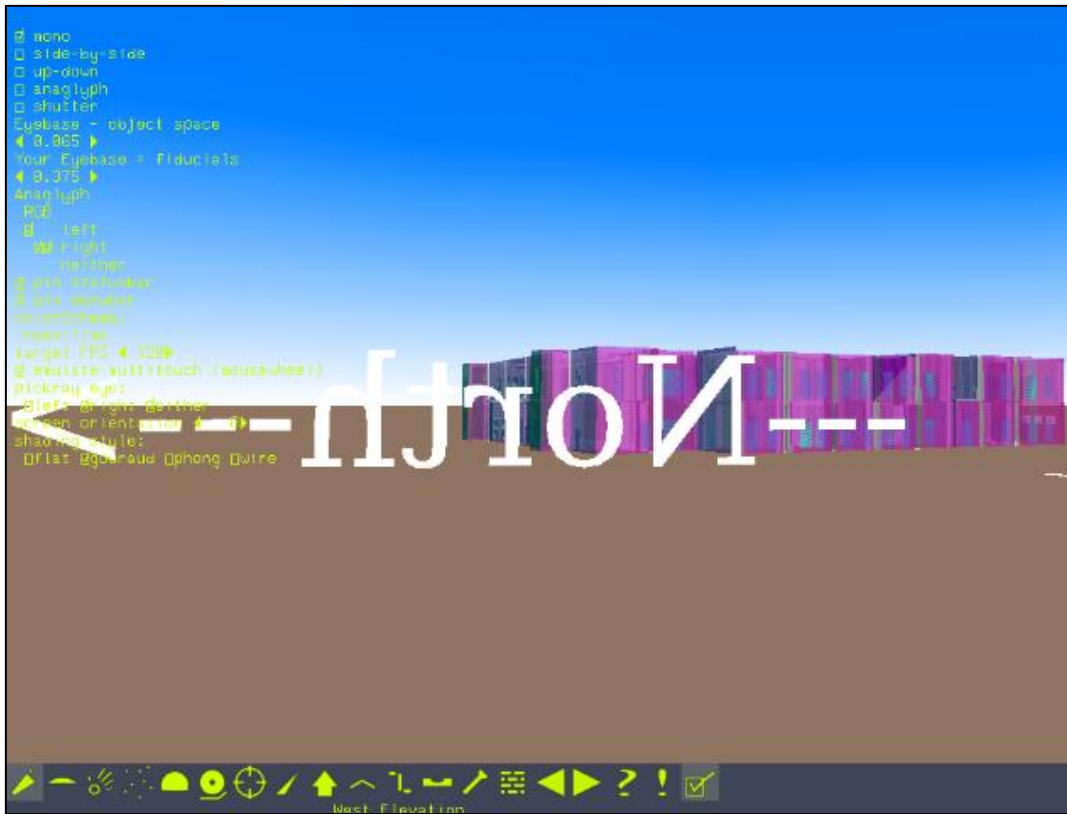


(b)

**Fig. 2.** Includes (a) realistic picture of case study, (b) 3D model in Autodesk Revit2018



**Fig. 3.** Export gbXML file process



**Fig. 4.** 3D VRML model view in GBS

#### 4. Case study

For the purpose of achieving the aim of the study, one of the educational buildings in Diyala University is selected as a case study, which is the Deanship of the agriculture Collage at Diyala University. This building consists of two floors with a total area(2924m<sup>2</sup>). The project was referred by Diyala University to foreign company in 2010 with an estimated cost about (1,693,308,500 ID). The project was stopped in 2011, in 2013 acceleration committee was formed from engineers at Diyala University to complete the remaining work and project was completed in 2018, other details of the building summarized below:

1. Project Location: Diyala, Iraq.
2. Type of Contract: Unit Price contract.
3. Project Supervision: Engineers from Diyala University.

4. Ground Floor: contain 36 rooms with height 3.65m.
5. First Floor: contain 46 rooms with height 3.65m.
6. Material type used for different building components illustrated in Table (1).

Motives and reasons for selecting the case study summarized as follow:

1. An educational building affiliated with Diyala University.
2. Availability of project information, where can get most of the information the researcher needs.
3. This project has been recently constructed and contains many details that help the researcher achieve the research objectives.
4. This project is taken as one of the projects for the education sector were selected as a case study for encouraging the application of green BIM in educational projects.

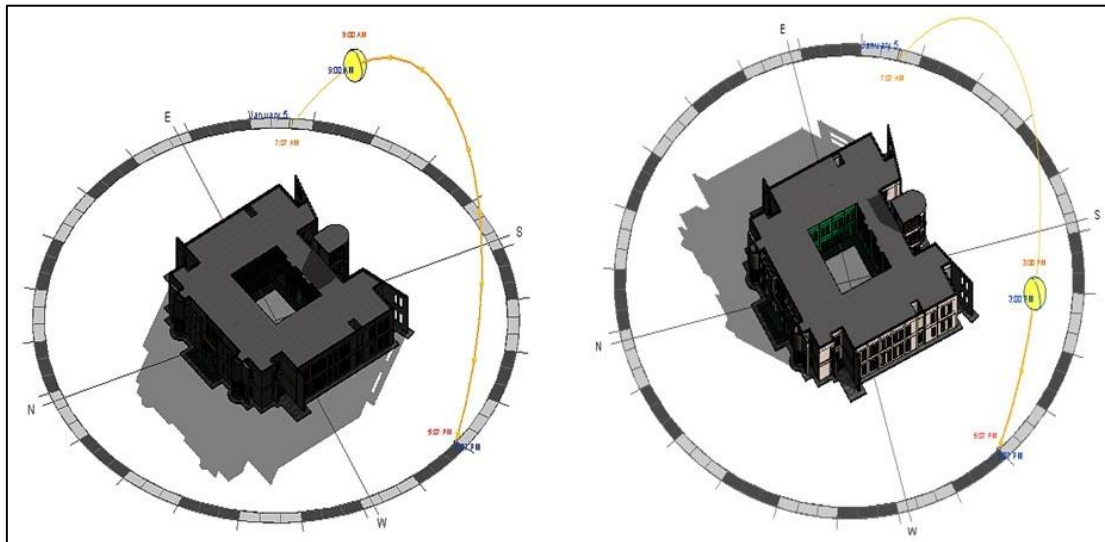
**Table 1** Material type of building components

Components	Material Type
Walls	Brick
Curtain walls	Double glazed
Roof	Normal concrete reinforced
Windows	Double glazed
Floor	Marble
Doors	Metal and wood

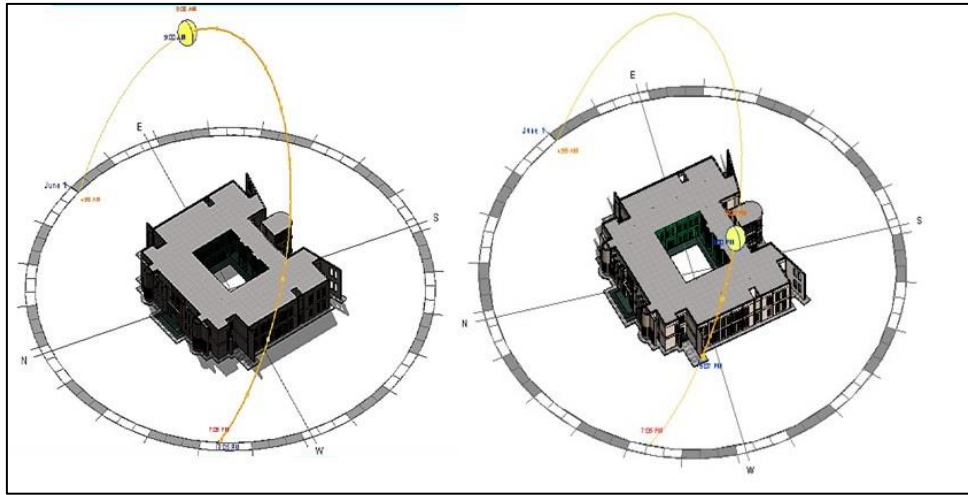
### 5. Sun path analysis

sun's path analysis allows for a visual interpretation of the position of the sun and its impact on the various parts of the building during different times from day or month and year. It also is helpful in visualizing the building's shadow during the entire day as well as help in assessment building orientation where helps designers find a suitable orientation for the building that can reduce energy consumption in the building.

The traditional methods were used in the design of the case study, so the orientation of the building did not receive much attention among the designers. Figure (4) illustrate sun path analysis in winter and summer seasons where through the analysis, the authors observed that the actual orientation of the building is not good because the front side of the building is not exposed to good sunlight during the day in the summer as well as in the winter.



(a) Sun path analysis in Winter season



(b) Sun path analysis in Summer season

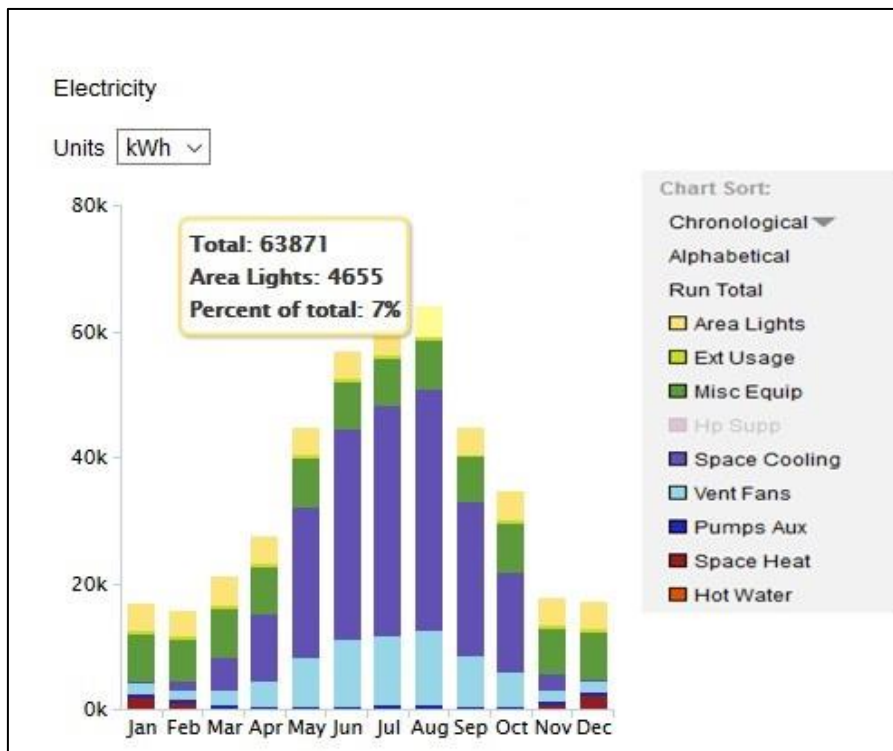
**Fig. 5.** Sun path analysis

## 6. Results and discussion

After the import gbXML file in GBS cloud, a complete simulation of energy performance is performed. The results were performed and discussed according to the following steps:

### 6.1 Monthly electricity energy analysis

Electricity energy analysis by using Green Building Studio gives a very detailed analysis, most electricity consumption goes for cooling space due to Iraq weather is considered dry and hot in most months as shown in figure as shown in Figure (6).



**Fig. 6.** Monthly electricity energy consumption

The total electricity consumption per month shows that there are large variations during the year,

which fluctuated between 15719KWh in February and 63871kWh in August as shown in table (2).

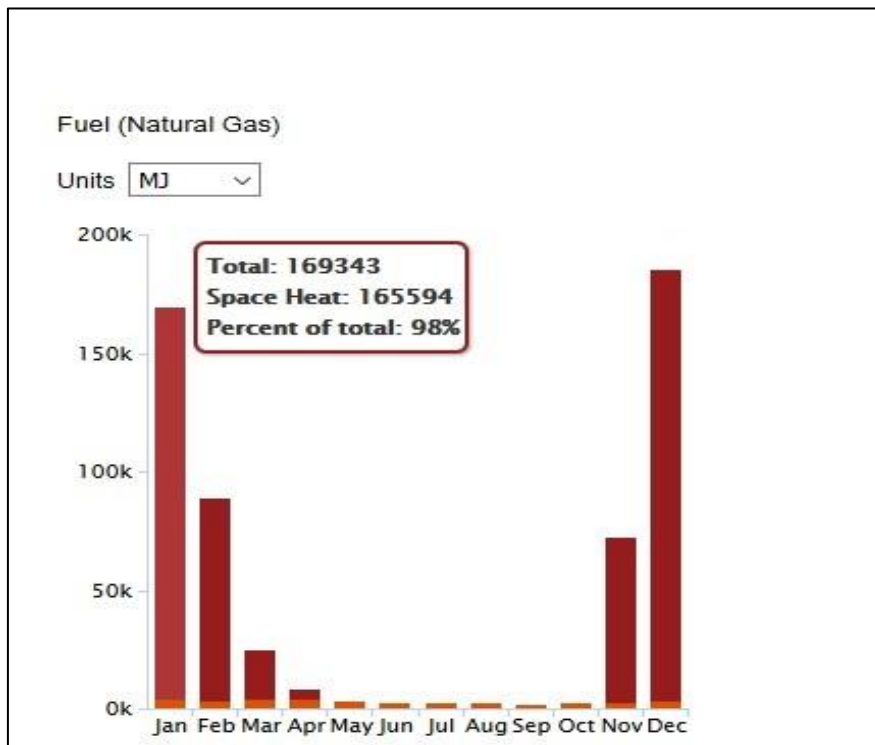
**Table 2** Variations of monthly electricity energy consumption

Run total \ M.th	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
<b>Total monthly of Electricity (Kwh)</b>	17024	15719	21128	27469	44871	56886	60641	63871	44712	34686	17728	16914
<b>Area Light</b>	26%	26%	22%	16%	10%	8%	7%	7%	9%	13%	24%	26%
<b>Misc. Equip</b>	45%	43%	37%	27%	17%	13%	12%	12%	16%	22%	41%	43%
<b>Space cooling</b>	0	9%	25%	39%	53%	59%	60%	60%	55%	46%	15%	0
<b>Ext Usage</b>	3%	3%	3%	2%	1%	1%	1%	1%	1%	2%	3%	3%
<b>Vent Fans</b>	10%	10%	11%	14%	17%	19%	18%	19%	18%	16%	10%	10%
<b>Pump Aux</b>	4%	3%	2%	2%	2%	0	2%	1%	1%	1%	3%	4%
<b>Space Heat</b>	11%	6%	0	0	0	0	0	0	0	0	4%	12%

**6.2 Monthly fuel analysis**

Most fuel consumption for the purpose space heat as shown in figure (7).

The total fuel consumption per month shows that there are large variations during the year, which fluctuated between 1975MJ in September and 187846 MJ in December as shown in table (3).



**Fig .7.** Monthly fuel consumption



**Table 3** Variations of monthly fuel consumption

M.th	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	De
<b>Run total</b>												
<b>Total monthly of Fuel (MJ)</b>	169343	88978	24498	7963	3280	2655	2313	2230	1975	2486	72067	187846
<b>Space Heat</b>	98%	96%	84%	54%	0	0	0	0	0	0	96%	98%
<b>Hot Water</b>	2%	4%	16%	46%	0	0	0	0	0	0	4%	2%

### 6.3 Comparison of simulated electrical energy results with real electrical energy consumption

The simulated electricity energy results are compared with real electricity consumption. The real electricity consumption available only for three months was obtained from the previous records of Diyala electricity office. Table (4) shows the greater error ratio between BIM and traditional around 35.5% in December where one

of the main reasons is electricity energy suffers from cut for several hours during the day where green building studio (GBS) is not designed to take care of this issue. The difference between BIM and traditional calculates according to the following Eq. (1).

$$\text{Error}\% = \frac{\text{BIM} - \text{Traditional}}{\text{BIM}} * 100\% \quad (1)$$

**Table 4** Comparison of simulated electrical energy results with real electrical energy consumption

NO.	Month	BIM (Electrical con. for 12 h) kWh	BIM (Electrical con. for 6 h) kWh	Traditional Consumption kWh	Error%
1	Jan	17024	8512	7241	14.9%
2	Feb	15719	7859	7593	3.4%
3	Mar	21128	10564	—	—
4	Apr	27469	13734	—	—
5	May	44871	22435	—	—
6	Jun	56886	28443	—	—
7	Jul	60641	30320	—	—
8	Aug	63871	31935	—	—
9	Sep	44712	22356	—	—
10	Oct	34686	17343	—	—
11	Nov	17728	8864	—	—
12	De	16914	8457	5449	35.5%

## 7. Conclusion

The construction sector is one of the most contributors to energy consumption and environmental impact. Therefore, authors trying to find suitable tools and strategies which help in energy management by adopting modern

techniques such as BIM technique. Through the results, the authors concluded the follows:

1. BIM very useful to perform various analyses that help to find different strategies for improving the energy efficiency of the project such as sun path analysis.

2. GBS tool based on BIM technique useful tool to energy analysis where result illustrate most energy electricity consumption goes for cooling space with consumption around 63871 kWh in Agust as well as most fuel consumption for the purpose space heat with consumption around 187846 MJ in December.
3. GBS tool based on BIM technique is effective tool which can help designers and architects to energy performance assessment in the early design stage where help in finding the best solutions that contribute to improving energy efficiency in the early stages of the project life cycle.
4. The results illustrate that there is a simple difference between simulated electric energy consumption versus the actual electric consumption that indicates using BIM very useful to evaluated energy performance in design stage.

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