Energy Performance Analysis of Building for Sustainable Design Using Bim: A Case Study on Institute Building

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Abstract- Around the world, global warming and energy consumption in the building had become the most important reasons to have directed the world's attention to energy-efficient building. Building sectors have increased parallel with the urbanization expansion in the developed countries, which increases the energy demand use in the building. External parameters and internal building components have a significant impact on the enhanced energy performance of the building. The use of energy assessment tools along with building information modeling could provide an effective contribution to support decision-making in the early design stages. This will enable a selection for proper building components and materials as well as minimize the influence on the overall energy consumption of buildings. This case study examines an education building located in the city of Alexandria (Egypt). The examine include life cycle electricity, fuel use, and life cycle energy cost along with the annual energy use intensity and annual peak demand considering four-building parameters (Orientation, Wall, Roof, HVAC) have been evaluated and compared with the initial design. This work enables stakeholders to have a previous virtual imagination to whole building components and to measure the total and annual energy need for each component, thereby driving to achieve near-zero-energy building as well as better cost-savings of building life cycle.

Keywords Building Information Modeling (BIM), Building Performance Analysis (BPA), Educational building, Energy Analysis, Green Building Studio (GBS).

1. Introduction

Energy demand in buildings has increased by 7% in just 8 years. The 2019 emissions gap report recommends reversing the trend of consuming energy. By improving energy efficiency in buildings at a rate of 2 to 3 % each year by 2025[1]. Using sustainable materials, better waste management, and energy from renewable sources are the suitable ways that can help the buildings to be very different compared with conventional buildings[2]. In 2018, the building sector represented 28% of global carbon dioxide emission. The rate of electricity demand in buildings has increased five times faster and Co_2 emissions increase two-thirds from rapidly growing electricity use. Since the year 2000, it is expected though that the building sector will see a Co_2 emission reduction of an average of 6% per year to 1/8 of current levels by 2050 according to International Energy Agency (IEA). It is estimated that decisive action by governments to support a sustainable building sector would save around 4.8 trillion U.S dollars globally over the next 30 years. Most buildings today use a lot of energy - to keep the lights on, power personal, cool the air, and heat water devices. Moreover, (IEA) reports that the use of air conditioning has been increased 33% in the 8 years from 2010[3][4].

Reducing energy consumption in buildings has a global concern to minimize the rise of the increased carbon footprint from the construction sector. Also enhancing energy efficiency in the development area is becoming essential in energy systems and strategies to achieve sustainable development goals[5][6]. Saving energy in a building has a significant impact on reducing the life cycle cost of the building component. The largest portion of the energy used in any residence or building is used in heating or cooling the indoor air. For example raising the temperature inside when it is cold outside[7][8]. Correspondingly, while it is very hot outside, to cool the houses and prevent the heat from entering the house. Some critical elements that have a significant impact on determining the amount of energy utilized in a building cover the climate region, building type, standard development, and level of modern technologies that determine the various properties and abilities of construction materials[9][10]. It is possible to substantially minimize the energy needed for space heating or cooling by wisely choosing the exterior wall, roof, door material, window material, and ground surfer, along with the architecture of the enclosed space that can have a crucial influence on the energy usage over a building's entire life cycle. Studies point out that the use phase in traditional buildings represent around 80–90% of the lifespan energy consumption, however, embodied energy accounts for about 10–20%[11]. It has been confirmed that saving energy is easier than generating it, thus, the value of maintaining buildings' energy efficiency for a variety of reasons is well determined. Over the building life cycle phases, the building phase is considered to be the phase that consumes high energy. This covers much of the operations related to the usage and maintenance of the house, such as comfortable air-conditioning, water use, and inside power systems[12][13].

Energy modeling techniques are also widely used in the building design process to estimate the energy needed to provide internal environmental comfort to achieve the desired degree of energy efficiency and to convey the traditional building to energy efficiency building[14]. The new technology of building information modeling BIM is considered as a revolution in construction building that offers features such as time savings, analysis processes, improved accuracy, and more rigorous design, and the ability to predict environmental performance for the building life cycle[15][16]. Also, the application of Building Information Modeling (BIM) and energy evaluation tools could make a substantial contribution in the choice of lower impactful materials and components, which have less influence on the overall energy usage of buildings[17][18]. These elements are, in most cases, selected only based on functional, financial, and technological conditions[19].

This paper discusses the current situation regarding sustainable design for existing institution buildings to enhance operating energy efficiency. Autodesk Revit and Green Building Studio have been used to select the optimal building component materials that improve building efficiency performances, therefore reducing the excessive expense of energy use in buildings life. Building location, weather station, climate databases, and building materials properties were the input data for the analysis phase as well as for compering and validation part to select the best scenario comparing with the initial design properties. As a result of decisions and strategies implemented to reduce energy demand and CO_2 emissions, the selection scenario supports the cost savings and environmentally sustainable impacts.

2. Methodology

An existing institute building was simulated using Revit Architecture 2018. To visualize the different sections of the building, a 3D model of the building was generated. The Revit file was transmitted to Green Building Studio as a gbXML file format, using Green Building Studio to measure the operating energy consumption. Using different materials in the modeling, the case study building was analyzed using various materials in the modeling to allow the energy consumption comparison. The components of a building that have a greater effect on energy dissipation, such as roof, wall, windows, and floor have been identified and investigated.

Two stages have been discussed in this paper, initially, the relevant information related to building type, existing building plan, materials properties, HVAC system, etc. According to input data about material and plan, the architectural model of the suggested building was created in Autodesk Revit-2018. Secondly, the inner energy analysis was completed using Green Building Studio (GBS).The design methodology of the work seen in figure 1.

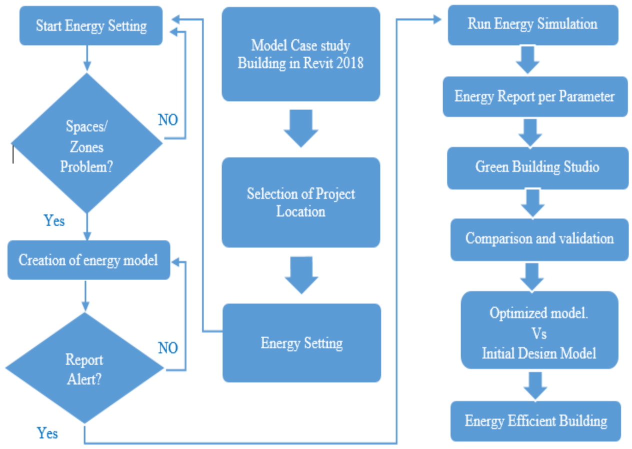

Fig. 1. Methodology of the work.

2.1. Building Description

The building is an existing building of an Institute located in the city of Alexandria, Egypt. The total floor area is of 5021m2, distributed through 6 levels (ground floor, 4 floors, and a roof), with a total floor area of 1396 m2, whereas each storey has an internal height of 3m. Each floor has a different function. The ground floor rooms cover administrative office, staffroom, archive office etc., whereas the remaining floors include hall, computer labs, service rooms etc. The top floor includes three big auditoriums with all service rooms as shown in figure 2. The coordinate of the building area is 31.024956184591698, 29.775375099261776. This location was chosen as a significant city on the southern coast of the Mediterranean, and it has a main change of temperature over a year. The temperatures vary from max: 30.5°C and min: 9.1°C.

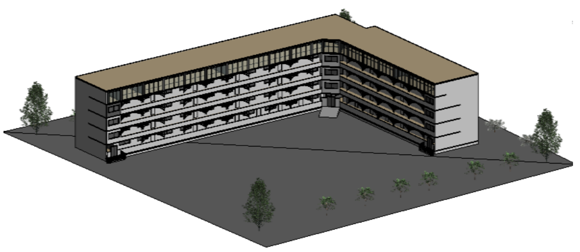

Fig. 2. 3D model plan of the existing education building

2.2. Energy Analysis Workflow

Autodesk Revit software was used to create 3D modeling of the examined education building, which is the design stage. The energy analysis part includes all the parameters that influence the energy results of the building. Those parameters contain building location, building types, weather station, building materials, building systems (HVAC), and internal loads[20][21]. The analysis result gbXML file is transferred to Autodesk Green Building Studio, which is a web-service that can investigate the environmental influences of building components during the design process[22]. The generating model of the building seen in figure 4. The result from GBS covers all the information regarding energy demands by month and years, thermal performance, solar radiation, total fuel, electricity cost and demand as well. Finally the water usage and weather result. The time taken to analyse the model lies between 10 to 15 minutes. Figure 3 shows the BIM energy analysis workflow starting from modeling 3D plan to getting the energy building results.

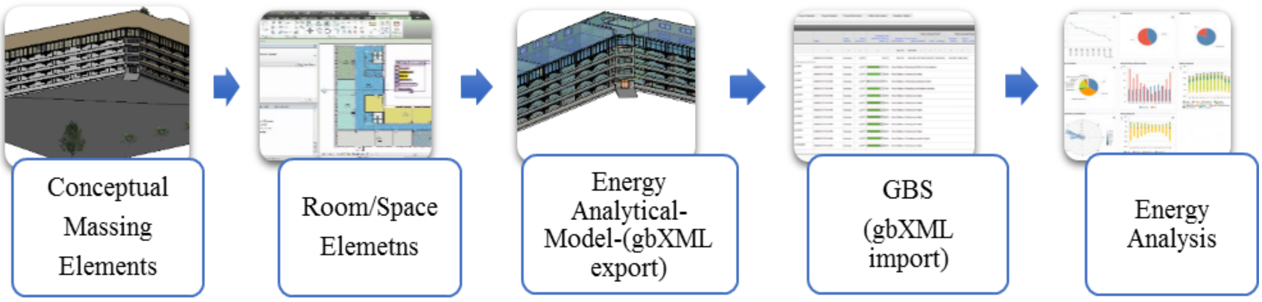

Fig. 3. BIM Energy Analysis Workflows

Building orientation and building location deem as remarkable parameter that has a significant influence on the energy use and can affect the total of energy used[23][24]. The selection of rooms for energy simulation needs to be as a separate operational spaces with a clear pick out of the zone and volume of those spaces[25][26]. Where the weather station in Alexandria can provide clear output data regarding the sun path and weather temperature. The average electricity cost and the fuel cost were 0.09 KWh, 0.78 therms respectively. However, there is a possibility to create different alternatives design using different factors for optimum consumer energy in building along with a low cost.

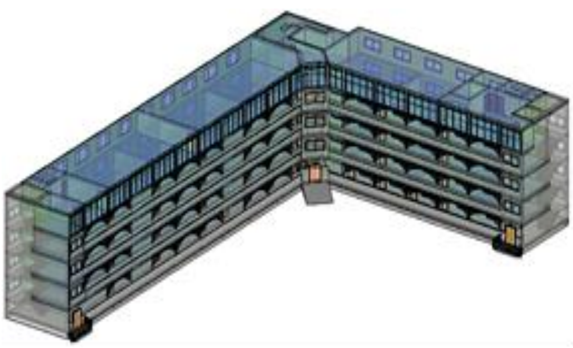

Fig. 4. 3D Energy analytical model of the analyzed building

3. Energy Analysis Result

3.1. Initial Design Energy Result

In order to estimate building energy consumption and operational costs, the DOE 2.2 dynamic thermal whole-building energy simulation engine is used by Green Building Studio[27][28]. This simulation focused on the influences and interactions of building shape, structures, materials, use, and environment. To evaluate the building performance analysis, the cloud service platform from the GBS system provided a whole result about energy use for instant annual energy cost, monthly heating, and cooling load, electricity, and fuel cost annual cost etc., water use, and carbon emission results[29].

3.1.1. Heating Load

According to the result obtained from energy building analysis, the amount of heating load that is gain or loss from building components during the operating year is seen in the figure 5. It can observe that the elements that are above the zero baselines can absorb heat and vice-versa, equipment, lights and window solar were the most components that contribute to earning the heating load over the operational year from the month of October to April, whereas the maximum heat earning was in January around 75 joules. On the other hand, window, wall, and roof conductions were responsible for nearly 112, 29, and 26 of heat loss respectively in January. As a result, it is necessary to improve the conductions of windows, walls, and roofs which will inhunce thermal environmental conditions during the winter season.

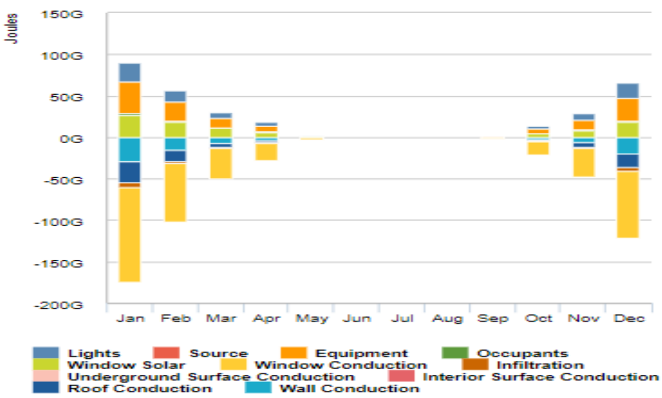

Fig. 5. Monthly heating loads

3.1.2. Cooling Load

The monthly cooling load acquired from energy analysis is clearly seen in the figure 6. Most of the heating load is above the zero baselines, whereas the maximum amount of heating load gain was nearly 450 joules from lights, equipment, occupants, and window solar during the period of four months, from May to August, in other words from the summer season. These components were responsible for only earning heating load during the operating year. It is noted from the figure 6 that the wall, roof, and window have low contribution regarding losing heat in the summer season. Thus it improves the insulation part of wall and roof components to be more energy-efficient, as well as using shading devices and upgrading the thermal properties of windows will maintain the thermal comfort in the building during the summer and winter seasons. Table 1 shows the cooling and heating load calculation result which was designed following the specifications of the ASHRAE Handbook of Fundamentals.

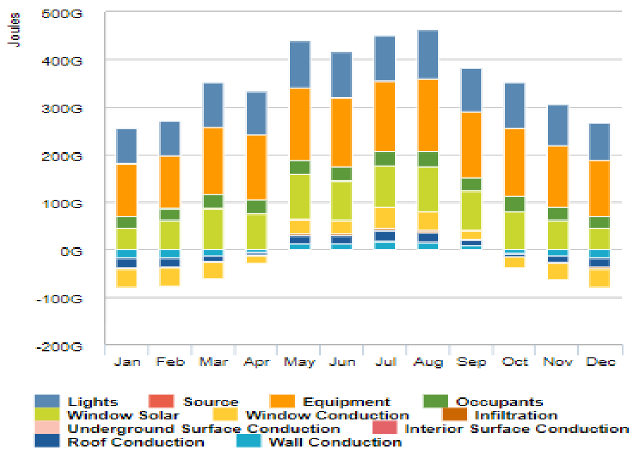

Fig. 6. Monthly cooling loads

Table 1. Revit 2018-Heating and cooling load calculation result.

Cooling Components	Total (W)	Percentage
Wall	200,184	18.04%
Window	64,748	5.83%
Door	643	0.06%
Roof	119,117	10.73%
Ventilation	316,579	28.52%
Lighting	53,665	4.84%
Power	43,744	3.94%
Fan Heat	19,516	1.76%
Heating Components	**Total (W)**	**Percentage**
Wall	170,660	35.07%
Window	38,963	8.01%
Door	614	0.13%
Roof	74,934	15.40%
Ventilation	201,427	41.39%

3.1.3. Electricity and Fuel Consumption

The total monthly electricity and fuel consumption are shown in figure 7. The maximum consumption value of fuel increased in winter during December, January, and February, while the maximum consumption value of electricity is shown in summer starting from April to September. The maximum value for fuel is nearly 190 kWh in January and around 140 kWh for electricity in the month of August.

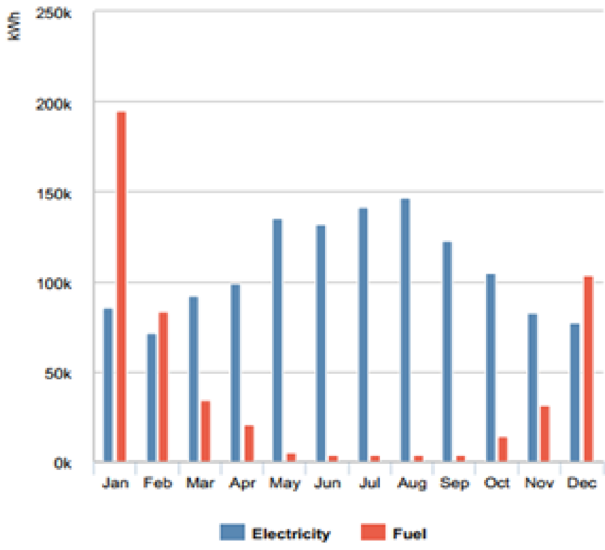

Fig. 7. Monthly Electricity and Fuel consumption

3.1.4. Energy Cost

The annual energy cost is shown in figure 8. The window glass, roof construction, and wall construction building have the total energy cost nearly to 3.22, 4.26, and 1.67 USD/m^2/year respectively.

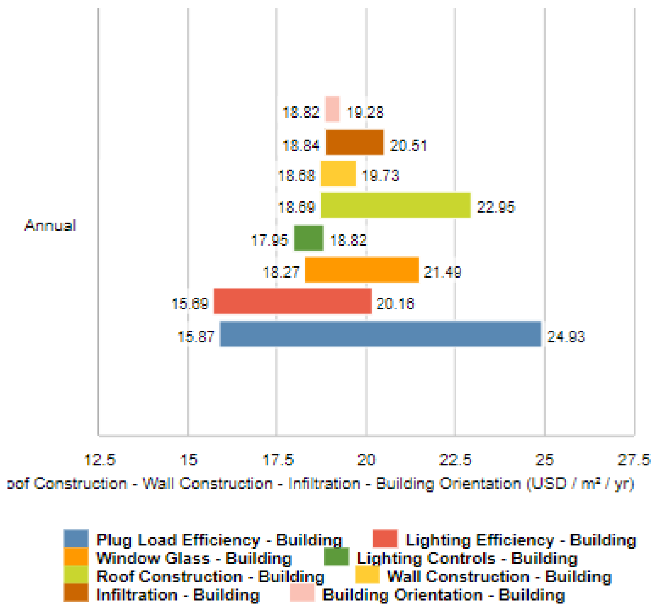

Fig. 8. Energy cost ranges

3.2. Evaluating Energy Consumption and Cost with a Standard Design

The validation of the building depends on the life cycle energy consumption as well as the annual cost of the energy. The calculations include the life cycle electricity and fuel use intensity along with the annual energy and cost. The dividing of total energy consumed in one year by the total gross floor area of the building is famous as energy use intensity (EUI), it is the mention to the total annual electricity and fuel energy consumed per square meter per year (MJ/m2/year). The cost of electricity and fuel during the building life cycle was $0.09 / kWh and $0.01 / MJ (equals 0.036 $/ kWh) respectively. The initial energy and cost results obtained from Autodesk GBS using standard design materials are shown in table 2.

Table 2. Initial energy and cost results.

Building Design	Total Life Cycle			Total Annual cost		EUI MJ / m² / year	Annual peak demand kW
	Electric use (kWh)	Fuel use (kWh)	Energy Cost ($)	Electric kWh/m²	Fuel kWh/m²		
Initial Design	22,018,384	3,559,443	939,096	$65,384	$3,173	584	260.2

3.3. Evaluating Energy Consumption and Cost with Alternative Parameter Studies

To understand the relationship between building components and factors that influence the amount of energy consumed in building, different parameters are investigated using GBS. Wall and roof materials, HVAC, and WWR was the internal parameters while the orientation of the building was external parameter. The initial building component details of wall, roof, and HVAC include description, dimensions, U-value, and thermal resistance R are presented in table 3 using Autodesk Revit software.

Table 3. Initial design details for building components.

Initial Design	Wall	Roof	HVAC
Definition	1-Normal Block + Two external and internal paint layer	Normal Concrete + Two external Ceramic tiles and internal Paint layer	Central variable air volume system. electric resistance heat boxes integrated with differential dry-bulb temperature economizer and variable volume chilled and condenser water pumps
Dimension	Block (9*19*19)cm Paint (0.1 cm)	Concert 18cm +(Ceramic 10cm),and Paint (0.1 cm)	
U-Value	5.4453 W/m2.K	6.9733 W/m2.K	
Thermal Resistance R	0.1836(m3.k)/w	0.1434(m3.k)/w	

3.3.1. Orientation

The initial parameter measured was the orientation of the building with the true north. The suitable building direction has a valuable contribution to minimize the energy consumption as well as maximize the ventilation and solar radiation in all climatic situations throughout the building life cycle operation period. The orientation of buildings can save heating, cooling, and light cost through better utilization of solar radiation, while the southern exposure considers as optimal building orientation for earning the maximum amount of heat in winter and lowering the cooling cost. In this case study, the useful angle for the building is 135. The effect of different orientations of the building on the annual energy use intensity and the life cycle electricity and fuel use consumption is seen in figure 9. Table 4 shows all the orientation alternative values. The difference between the initial design value and optimum value is nearly 11 kWh/m2. However, by considering the building area 5021m² the effect of 55220 kWh /year total annual energy save from building direction.

Table 4. Energy use, and cost based on the orientation alternative

Building component: Orientation							
Alternative Material	**Life Cycle Electricity Use (kWh)**	**Life Cycle Fuel Use (kWh)**	**Life Cycle Energy Cost ($)**	**Annual EUI cost (kWh/m²)**	**Annual FUI cost (kWh/m²)**	**Annual EUI (kWh/m²)**	**Annual peak Demand KW**
0	21197334	3564737	934,151	65409	3177	585	260.3
45	20827866	3534304	930,820	65191	3150	582	259.5
90	20650290	3452773	922,260	64635	3078	576	258.7
135	20620587	3355259	985,810	64542	2991	573	257.4
180	20681454	3309846	921,853	64733	2950	573	261.0
225	20686020	3330782	922,302	64747	2969	574	260.1
270	20677005	3541108	924,472	64719	3156	579	259.1
315	21114603	3718178	932,488	65150	3314	586	259.2

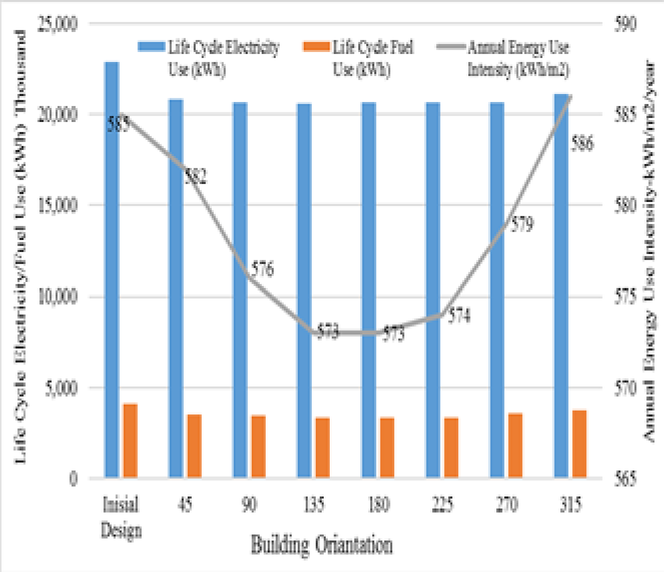

Fig. 9. Comparison of the various orientation direction

3.3.2. Wall Alternative

The evaluation of eight alternative wall construction components recommended from green building studio such as Uninsulated, R2 CMU, Insulated Concrete Form (ICF), R13 Metal etc, which were analyzed and compared with the initial design. Table 5 shows the alternative wall analysis details including energy and cost for the annual and life cycle of the building as an alternative component. It is noted from figure 10 that uninsulated, R38 Wood and CMU wall construction has the highest life cycle energy use and cost values among the other options, while the R13Metal, R13+R10 Metal options have little values comparing with alternative components. But usually, it is used for commercial or manufactory buildings. While comparing the remaining options Insulated Concrete Form (ICF), and Structural Insulated Panel (12.25-inch SIP) components. The SIP wall is typically used on smaller buildings, (ICF) has a more energy-efficient, durable construction, reducing the amount of energy required to heat and cool the building. less air infiltration, sturdy compared to conventional metal and wooden construction.

Table 5. Energy use and cost based on the wall alternative.

Building Component: Wall							
Alternative Material	**Life Cycle Electricity Use (kWh)**	**Life Cycle Fuel Use (kWh)**	**Life Cycle Energy Cost ($)**	**Annual EUI cost (kWh/m^2)**	**Annual FUI cost (kWh/m^2)**	**Annual EUI (kWh/m^2)**	**Annual peak Demand KW**
Uninsulated	23,573,584	4,220,641	$963,678	$65,882	$3,514	587	263.8
R13 Metal	20,690,187	3,984,243	$920,041	$64,760	$3,304	583	261.6
R13 Wood	20,898,339	3,842,220	$921,190	$65,412	$3,177	585	262.5
R13+R10 Metal	20,925,939	3,713,207	$919,800	$65,498	$3,162	582	262.6
14-inch ICF	18,296,403	3,330,831	$756,175	$65,229	$3,016	581	260.5
R38 Wood	21,033,429	3,487,925	$937,671	$65,835	$3,110	583	262.8
R2 CMU	23,353,072	3,903,843	$957,906	$65,631	$3,356	586	263.5
12.25-inch SIP	18,789,309	3,321,193	$791,745	$65,345	$3,015	582	261.2

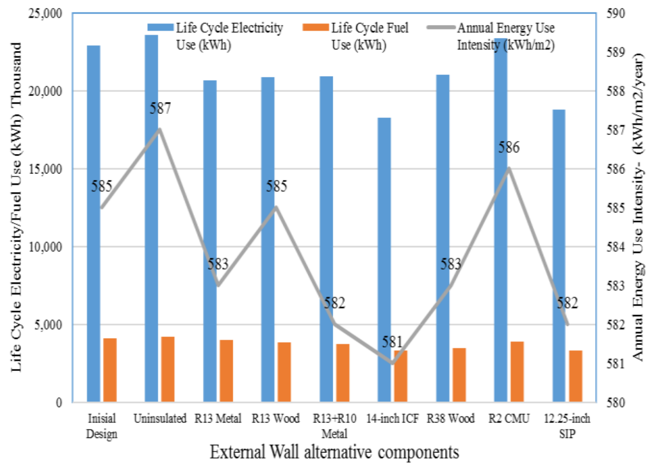

Fig. 10. Comparison of the various wall alternative components

3.3.3. Roof Alternatives

Different types of roof materials were evaluated to find the optimum option for selecting an alternative roof. Table 6 shows the different types of roofs such as roof-uninsulated, R10, R19, R38, R60, 10.25-inch SIP, and R15. The different type of resistance (R) depends on the thermal resistance grade of the insulating material, while the increase of the R-value refers to the best insulating efficiency of the building. The best R-value has an impact on the life cycle costs, indoor air quality, and embodied energy. Figure 11 shows that life cycle energy cost has reduced with the change of roof construction R-Value. Among the options, the roof construction R60 and 10.25-inch SIP almost shares the same life cycle Electricity, Fuel use, and energy cost values. However, the roof construction 10.25-inch SIP has minimized the lifespan cost with 931,381$. Table 6 show the energy use, and cost based on the roof alternative.

Table 6. Energy use and cost based on the roof alternative.

Building component: Roof							
Alternative Material	**Life Cycle Electricity Use (kWh)**	**Life Cycle Fuel Use (kWh)**	**Life Cycle Energy Cost ($)**	**Annual EUI cost (kWh/m^2)**	**Annual FUI cost (kWh/m^2)**	**Annual EUI (kWh/m^2)**	**Annual peak Demand KW**
Initial Design	22,918,384	4,115,003	955,696	65,788	3,173	585	262.4
Uninsulated	21,818,928	4,559,356	985,517	68,293	4,064	591	268.8
R10	20,968,209	3,672,806	938,485	65,630	3,274	589	259.1
R19	20,966,448	3,592,320	937,433	65,625	3,202	587	259.9
R38	20,202,479	3,465,523	933,166	65,425	3,089	582	259.8
R60	19,860,369	3,147,811	861,738	65,356	3,053	581	259.9
10.25-inch SIP	19,855,139	3,154,295	851,381	65,324	3,059	581	258.2
R15	20,912,454	3,605,520	935,291	65,456	3,214	586	259.8

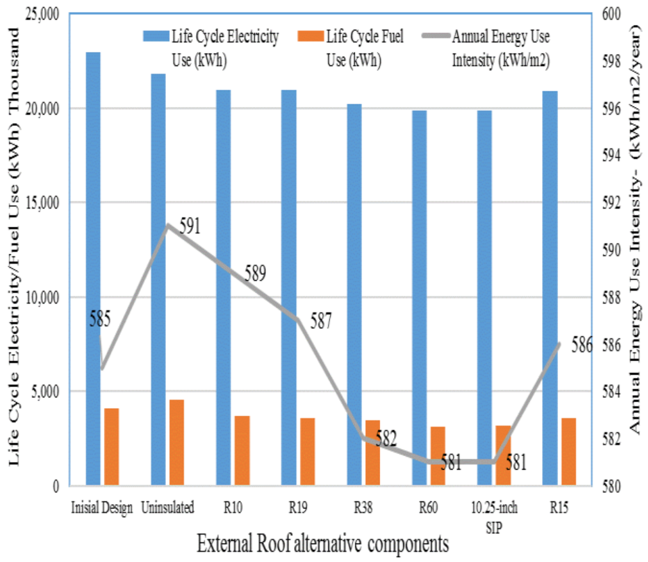

Fig. 11. Comparison of the various roof alternative components

3.3.4. HVAC System

HVAC has an important effect on the building life cycle's energy use. The main purpose of using HVAC is to improve the acceptable indoor air, thermal comfort as well as controlling the cooling and heating temperature load for commercial and residential buildings. Selecting the type of HVAC depends on the various parameters that are related to the building area, weather conditions, insulation type, number and type of windows, etc. Table 7 shows the various options of HVAC such as ASHRAE Package System, High Eff. Heat Pump, ASHRAE Heat Pump, High Eff. Package System, High Eff. VAV, ASHRAE Package Terminal Heat P, High Eff. Packaged Terminal AC, which are reordered as HVAC type-1 to HVAC type-7. Figure 12 shows that both type-5 and type -6 nearly have similar values in life cycle electricity use as well as the life cycle energy cost and differs from each other's in life cycle fuel use annual energy use intensity (EUI). Type-6 which refers to the name ASHRAE Package Terminal Heat P has a lower cost comparing as well as lower annual energy use intensity comparing with similar options.

Table 7. Energy use and cost based on the HVAC alternative.

Building component: HVAC							
Alternative Material	**Life Cycle Electricity Use (kWh)**	**Life Cycle Fuel Use (kWh)**	**Life Cycle Energy Cost ($)**	**Annual EUI cost (kWh/m^2)**	**Annual FUI cost (kWh/m^2)**	**Annual(EUI) (kWh/m^2)**	**Annual peak Demand KW**
Types1	19,292,289	2,638,496	854,480	$60,385	$2,352	524	253.0
Types2	18,269,583	2,189,900	805,434	$57,184	$1,952	489	222.1
Types3	20,072,409	2,463,656	885,614	$62,827	$2,196	539	275.7
Types4	18,159,075	2,609,513	805,819	$56,838	$2,326	496	211.9
Types5	17,406,975	3,574,703	785,476	$54,484	$3,186	501	212.4
Types6	17,441,892	2,463,656	773,474	$54,593	$2,196	476	218.2
Types7	17,984,919	2,867,310	801,525	$56,293	$2,556	498	224.4

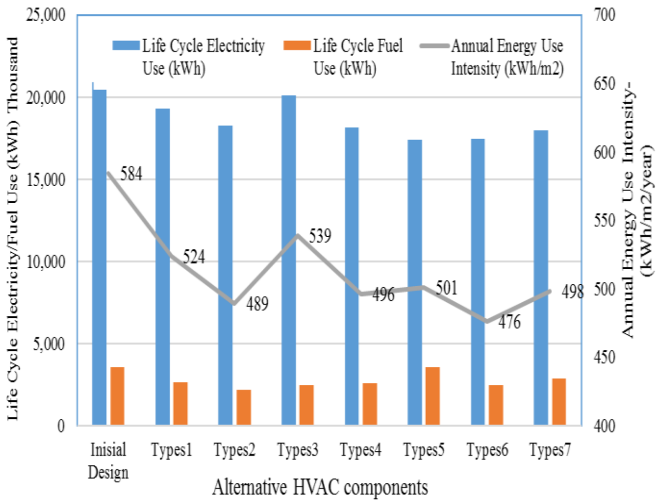

Fig. 12. Comparison of the various HVAC alternative

4. Major Finding and Discussion

This work evaluates the energy performance and cost analysis of existing parameters and building components from the Green Building Studio. Depending on the previous evaluation analysis process for each parameter of the building, the energy and cost analysis of recommended parameters is compared with the standard design as shown in table 8.

Table 8 shows the improvement that has been added from the suggestion parameters comparing to the initial design parameters, which can have an important influence on improving the building energy consumption and life cycle cost as well. It can observe the positive variation in the annual electricity cost around 28.20 % and annual fuel cost around 46.70% compared with the standard design. In addition to that, the significant enhancement in the annual energy use intensity and annual peak demand are nearly to 30% and 7.4 % respectively. Figure 13 summarizes the analytical part that includes the analysis of external and internal parameters that have a valuable impact on enhancing the initial design building using suggested parameters. The following points highlight the main variation as well as the improvement of using suggested parameters.

Table 8. Initial design and suggested design energy use, and cost based on alternative options.

Building Design	Total Life Cycle use			Total Annual cost		(EUI) MJ / m² / year	Annual peak demand kW
	Electric (kWh)	Fuel (kWh)	Energy Cost ($)	Electric kWh/m²	Fuel kWh/m²		
Initial Design	22,918,384	4115003	$955696	$65,788	$3,173	584	262.4
Suggested designs	16,455,482	2,358,323	745,103	$54,646	$2,390	409	242.9

I. Comparing suggested parameters with the initial design parameters for whole-building energy analysis enhances the life cycle electricity, fuel use, and energy cost nearly 28.20%, 42.70%, and 22.30% respectively.

II. Comparing suggested external orientation parameter have improved the life cycle electricity, fuel use, and energy cost nearly to 10%, 18.47%, and 7.32% respectively.

III. Comparing the suggested parameter with the initial design parameters for external parameters wall only will enhance the life cycle electricity, fuel use, and energy cost nearly to 20.16%, 19.10%, and 21 % respectively.

IV. Comparing the suggested internal roof parameter with the initial design parameter will enhance the life cycle electricity, fuel use, and energy cost by around 13.36%, 23.35%, and 11% respectively.

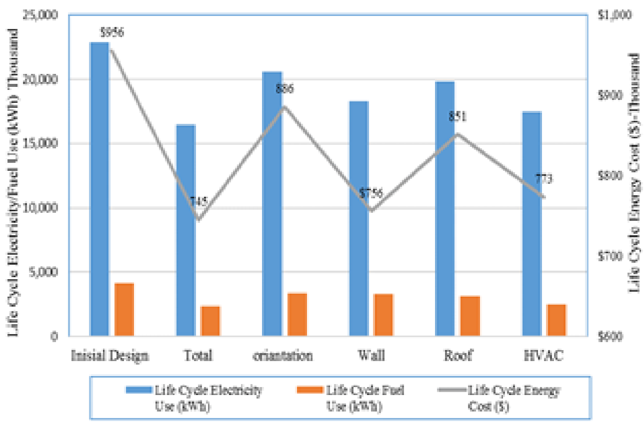

Fig. 13. Analysis of the life cycle of energy use/cost for alternative options in the building

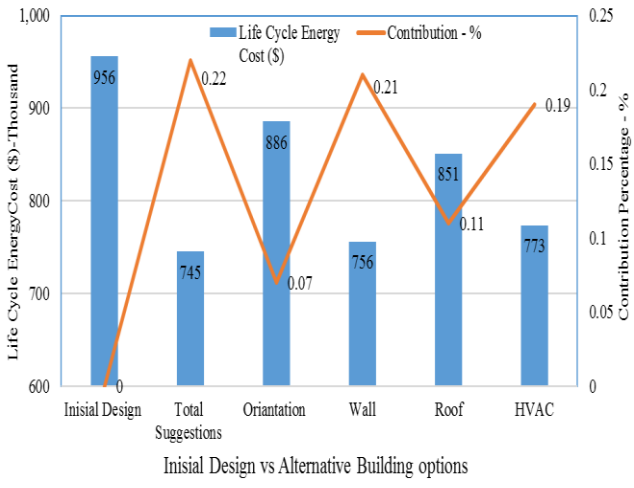

Fig. 14. Analysis of the life cycle energy cost contribution for alternative options in the building

V. Comparing the suggested HVAC system with the initial design system will improve the life cycle energy analysis by nearly 24%, 40.12%, and 19.14% respectively.

The figure 14 explains the influence of contribution percentage of each building parameters on the life cycle energy cost and it was confirmed that the wall and HVAC have the highest contribution on the energy cost 0.21% and 0,19% respectively while the orientation and the roof have the low contribution on the energy cost 0.07% and 0.11% respectively. Moreover, the total suggested modification parameters have a 22% significant improvement on the building life cycle energy cost.

5. Conclusion

BIM tools help to evaluate the energy efficiency and cost of the existing building using Autodesk Revit 2018 and Green Building Studio, considering different external parameters and internal construction components such as orientation, wall, and roof, and HVAC as well.

- This work evaluates the recommended parameters comparing with the standard design parameters that would have a significant effect on the operating energy consumption via enhances the life cycle electricity, fuel use nearly 28.20%, 42.70%, and minimize the annual energy cost almost 22.30% during the building life cycle.

- The overall result explains the noteworthy enhancement of 22% in the recommended building parameters comparing with the initial design for designing self-sustained energy-efficient buildings that can have a significant advantage for both building owners as well as to the society.

- The contribution of building parameters on the life cycle energy cost have been varied, while the wall and HVAC have the highest contribution 0.21% and 0,19% respectively. The orientation and the roof have a low contribution 0.07% and 0.11% respectively

- The result clarifies that the recommended parameters increase the energy performance as well as achieve the aim of the building sustainability objectives environmental, financial, and social benefits.

- Furthermore using a different type of materials with different energy performance enable project stockholders to have a right decision at the early stages of the construction process.

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