T.C.
ISTANBUL GEDİK UNIVERSITY
INSTITUTE OF GRADUATE STUDIES

CASE STUDY ON BIM APPLICATION FOR NZEB OF THE EXISTING STRUCTURE

MASTER'S THESIS

Shaimaa AL-RUBAII

Engineering Management Department

Engineering Management Master in English Program

DECEMBER 2021

T.C.
ISTANBUL GEDİK UNIVERSITY
INSTITUTE OF GRADUATE STUDIES

CASE STUDY ON BIM APPLICATION FOR NZEB OF THE EXISTING STRUCTURE

MASTER'S THESIS

Shaimaa AL-RUBAII
(181281013)

Engineering Management Department

Engineering Management Master in English Program

Thesis Advisor: Asst. Prof. Dr. Ahmet GULLU

DECEMBER 2021

T.C.
İSTANBUL GEDİK ÜNİVERSİTESİ
LİSANSÜSTÜ EĞİTİM ENSTİTÜSÜ MÜDÜRLÜĞÜ

Yüksek Lisans Tez Onay Belgesi

Enstitümüz, Engineering Management Department İngilizce Tezli Yüksek Lisans Programı (181281013) numaralı öğrencisi Shaimaa AL-RUBAII'nin "Case Study on BIM Application for Nzeb of the Existing Structure" adlı tezçalışması Enstitümüz Yönetim Kurulunun 16/12/2021 tarihinde oluşturulan jüri tarafından *Oy Birliği* ile Yüksek Lisans tezi olarak *Kabul* edilmiştir.

Öğretim Üyesi Adı Soyadı

Tez SavunmaTarihi: 16.12.2021

1) Tez Danışmanı: Dr. Öğr. Üyesi Ahmet GÜLLÜ

2) Jüri Üyesi: Dr. Öğr. Üyesi Gökhan KAZAR

3) Jüri Üyesi: Dr. Öğr. Üyesi Hasan ÖZKAYNAK

DECLARATION

I, Shaimaa AL-RUBAII, do hereby declare that this thesis titled as "Case Study on BIM Application for Nzeb of the Existing Structure" is original work done by me for the award of the masters degree in the faculty of Engineering Management. I also declare that this thesis or any part of it has not been submitted and presented for any other degree or research paper in any other university or institution. (16/12/2021)

Shaimaa AL-RUBAII

DEDICATION

To my father, brothers, sisters, friends, and everyone who supported me.

To all my teachers throughout my study journey who effectively contributed to lighten my way.

To everyone made me drink from the glass of doubt to start seeking for the truth.

All the mentioned come after the most generous person in my life, my mother.

PREFACE

I am pleased to thank my parents and brothers for their continuous support throughout my academic career.

I thank all my friends for their support and encouragement. I am pleased to extend my thanks to everyone who advised, guided, or contributed to this research preparation.

I especially thank my teacher (Dr. Ahmet Gullu & professor.Dr_Ing “Koch” & M.Sc. Mohamed Said Helmy Alabassy) for their support and advice. I also thank the university, the head of the department, and the discussion committee members.

December 2021 Shaimaa AL-RUBAII

TABLE OF CONTENTS

Page

ABBREVIATIONS

BIM	: Building Information Modeling
EU	: European Union
NZEB	: Nearly Zero Energy Building
PMBOK Guide	: The Project Management Body of Knowledge Guide
PMI	: The Project Management Institute
UK	: The United Kingdom
US	: United States
USA	: United States of America
ZEB	: Zero Energy Building

LIST OF TABLES

Page

LIST OF FIGURES

Page

CASE STUDY ON BIM APPLICATION FOR NZEB OF THE EXISTING STRUCTURE

ABSTRACT

Energy of all kinds is one of the basic requirements in life for its sustainability. Therefore, the majority of research and applications focus mostly on promoting energy self-sufficient buildings or zero-energy buildings in developed countries. Most of these countries are experiencing energy renewal, which is currently being built to reduce carbon dioxide emissions for existing buildings. Hence, energy-saving applications should spread across developing and undeveloped countries. Most of the studies focused on the design of new buildings that are self-sufficient in terms of energy, but in this study, the focus is on converting existing buildings into buildings with zero or close to zero energy using building information modeling programs, where a model is taken for an elementary school in Iraq as a case study, and the model is drawn using Autodesk Revit 2020 software, and then analyzing it using Autodesk Insight 360 software, after determining the equipment of the building in terms of its location, type of construction, the number of operating hours in the building, in addition to the type of heating and cooling system used in the building, where worked during the research on the sixth dimension of Building Information Modeling (BIM). It is the part of the sustainability and energy analysis of buildings where the results show that it is possible, after using the improvement options proposed through the Insight program, to obtain an energy reduction in the building of 54% percent, but with considering the cost of conversion and the time required, it is found that it is not the optimum option. So, an other solution was suggested, which is a very popular solution in almost all over the world, the photovolatic panels. Iraq has a very high annual global irrediation, also the empty wide roof area of the building have made the PV panels to supply all the required energy consumption. By calculating the investment cost on PV panels system, and the annual consumption of the building, it is found that the payback period is obtained to be 8.3 years by using PV system. In addition to the economic feasibility of this option which can be considered as acceptable, it can also decrease the CO_2 emission which leads to help to achieve the requirements of green building.

Keywords: *Building information modeling, Sustainability, Energy analytics, Photovoltaic panels.*

MEVCUT YAPININ NZEB'Sİ İÇİN BIM UYGULAMASINA İLİŞKİN ÖRNEK OLAY İNCELEMESİ

ÖZET

İş çalışma, zayıf planlamanın şu anda yapılan Irak'taki inşaat projelerinin geciken uygulanması üzerindeki etkisinin kapsamını açıklığa kavuşturmak amacıyla

Her türlü enerji, sürdürülebilirliği için yaşamın temel gereksinimlerinden biridir. Bu nedenle, araştırma ve uygulamaların çoğu, gelişmiş ülkelerde çoğunlukla kendi kendine yeterli enerjiye sahip binalara veya sıfır enerjili binalara odaklanmaktadır. Bu ülkelerin çoğu, mevcut binalar için şu anda karbondioksit emisyonlarını azaltmak için inşa edilen enerji yenilemesiyle karşı karşıya. Bu nedenle, enerji tasarrufu uygulamaları gelişmekte olan ve gelişmemiş ülkelerde yaygınlaştırılmalıdır. Çalışmaların çoğu, enerjide kendi kendine yeterli yeni binaların tasarımına odaklanmıştır, ancak bu çalışmada, bir modelin kullanıldığı bina bilgi modelleme programları kullanılarak mevcut binaların sıfır veya sıfıra yakın enerjili binalara dönüştürülmesine odaklanılmıştır. Irak'ta bir ilköğretim okulu için örnek olay incelemesi olarak alınmış ve model, tüfek programı kullanılarak çizilmiş ve daha sonra Insight programı kullanılarak analiz edilmiş, binanın donanımı, konumu, yapım şekli, sayısı bakımından belirlendikten sonra. Bina Bilgi Modellemesinin (BIM) altıncı boyutu ile ilgili araştırmamız sırasında çalıştığımız binada kullanılan ısıtma ve soğutma sisteminin türüne ek olarak, binadaki çalışma saatleri, sürdürülebilirlik ve enerji analizinin bir parçasıdır. Binaların sürdürülebilirlik ve enerji analizinin, Insight programı aracılığıyla önerilen iyileştirme seçeneklerini kullandıktan sonra, ancak maliyet göz önünde bulundurularak binada yüzde 54 oranında bir enerji azaltımı elde etmenin mümkün olduğunu gösterdiği, binaların sürdürülebilirlik ve enerji analizinin bir parçasıdır. dönüşüm ve gereken süre göz önüne alındığında, bunun optimum seçenek olmadığı bulunmuştur. Bu nedenle, hemen hemen tüm dünyada çok popüler bir çözüm olan başka bir çözüm, fotovolatik paneller önerildi. Irak'ın yıllık küresel ısınması çok yüksek, ayrıca binanın boş geniş çatı alanı, PV panelleri gerekli tüm enerji tüketimini sağlayacak hale getirdi. PV panel sistemi yatırım maliyeti ve binanın yıllık tüketimi hesaplanarak, PV sistem kullanılarak geri ödeme süresinin 8,3 yıl olduğu tespit edilmiştir. Kabul edilebilir olarak değerlendirilebilecek bu seçeneğin ekonomik fizibilitesine ek olarak, yeşil bina gereksinimlerinin karşılanmasına yardımcı olan CO2 emisyonunu da azaltabilir.

Anahtar Kelimeler: *Bina bilgi modellemesi, Sürdürülebilirlik, Enerji analitiği, Fotovoltaik paneller*

1. INTRODUCTION

Energy use, climate change, and poverty due to lack of energy are all major issues that societies are grappling with. Furthermore, the rise in energy prices has boosted the renewable energy sector, lowering the costs of renewable energy technologies such as wind, hydropower, solar, biomass, biofuels, and geothermal.

This prompted a major development in energy-saving technologies. One of these developments will be the design and/or renovation of more sustainable residential and commercial buildings to achieve energy neutrality .

A sustainable building preserves structural integrity while also considering the health, safety, and comfort of its users, as well as energy efficiency and environmental consequences. Development of novel sources and technologies yielded to create energy self-sufficient societies. For instance, The Netherlands aimed to reach an energy-neutral built environment by 2050. Possible alternatives to reach this purpose were also investigated for low- and mid-rise structures and applied some effort has been paid to find out efficient renovation alternatives for single-family houses or high-rise apartments in The Netherlands .(Davide and Bauke, 2015; Sultan, 2018; Joris, 2020).

(Louise et al.,2018) also stated that the relatively novel concept in Australia creates substantial opportunities to reduce greenhouse gas emissions, energy usage, and cost. It was also mentioned that governmental encouragement and acceptance of the societies for net-zero energy buildings have a major role to reach an energy-sufficient environment. (Shady et al.,2017) show that there are some factors equally important with the economic challenge that hinder renovation of existing buildings or design new ones in line with a net or nearly zero-energy concept in southern European countries. These factors are listed to be technical development, organizational issues, legislation and enforcement, and awareness. The Ministry of urban and environment of Turkey has also released a guide for the design of nearly zero-energy buildings (Turkish Ministry of Environment, Urbanisation and Climate Change, 2020, NSEB) Even though, in the underdeveloped or developed countries there are still some issues to be solved that they should adopt to zero energy concept to increase their growth speed. Current energy sources are not infinite and should be replaced with renewable alternatives.

Hence, a total floor area of 2070 square meters conventional primary school building located in Baghdad, Iraq is considered as the case in this thesis to study the management of energy using BIM in short. It is an attempt to model all building information so that it is accessible to all project participants throughout the life cycle of the building. It is dealt with through Revit program.

There is a complete reliance on program information as this smart program utilizes all the elements, not the lines of a given case. So, an observer can find the basic tools inside Revit as, columns, walls, doors and tubes. Each of these elements has a classification within Revit according to the general characteristics of the family to which the element belongs and the direct characteristics that depend on its location, the level specified in it, and the stage of its construction. Although, many programs provide 3D simulations such as (3ds Max), these programs deal with abstract models such as cubes and balls, and the user just molds them to achieve the final shape they desire, but in BIM tools, they get the feeling that everything they do is already buildable on a computer screen from the first moment (Doulos et al.,2019)

1.1 Study Topic

The recent trend towards sustainable buildings is obvious in new construction, as architects and contractors emphasize the use of green technologies in the construction process, as well as ensuring that the building is used by environmentally friendly norms. Renovations and additions follow the same standards. Some steps must be taken to make the existing buildings follow the same green life opportunities expected from new buildings by improving the performance of the current building and converting it from an ordinary building to an environmentally friendly building.
In this thesis, the conversion of an existing conventional building to the zero-energy concept will be discussed.

1.2 Purpose of Thesis

This work focuses on economic feasibility to convert an existing building into an environmentally friendly building using Building Information Modeling. As the main goal of the research is to reduce in emission the energy costs spent in the building as much as possible and reach a result of saving in the annual costs of energy.

Through the research, it is tried to come up with a proposed procedural approach to have a very developed universe that is environmentally friendly. In doing so, there will be an ability to fulfil the future needs with the lowest possible consumption of energy.

In order to achieve high efficiency in buildings, NZEB should be required to achieve ambitious reductions in energy and carbon emissions using agreed and well-defined indicators. , which is essential for the construction industry to develop solutions in a stable and coherent framework. This is critical because in 2020, all new buildings must be highly energy efficient, and very low or very low energy demand will have to be covered to a large extent by renewables.

(Soytas and Ramazan ,2007) studied the impact of energy consumption and income on carbon emissions in the United States. The results indicate that carbon emissions are not affected by an increase in income in the long run. On the other hand, there is a Granger causal relationship between energy consumption and carbon emissions in the United States. This means that energy consumption time series can be used to estimate US carbon emissions. (Say and Yucel,2006) studied the energy sector in Turkey for the period 1970-2002 and, as a result of the regression analysis, they found a strong relationship between total energy consumption (TEC) and total carbon emissions (TCO2). They also concluded that typical consumption of electricity is mainly related to economic growth.

(Wang and Lili**,** 2016) attempted to quantify the relationship between urbanization, energy consumption and carbon emissions in the Association of Southeast Asian Nations (ASEAN) for the period 1980-2009. Co-integration test results showed a long-term equilibrium relationship between urbanization, energy consumption and carbon emissions. The results indicate a causal relationship between urbanization, energy consumption and carbon emissions. Accordingly, energy consumption has a positive effect on increasing carbon emissions.

Therefore, this research aims to provide solutions for net energy renewals from scratch as well as for commercial and service buildings in terms of carbon dioxide emissions, thermal comfort, and cost. To support the objective of the research, the following questions are taken into consideration:

1. What modeling accuracy should be chosen to simulate energy in buildings?
2. What design modification solutions/techniques are available?
3. What is the performance of these solutions/technologies?

1.3 Literature Review

Most of the statistics indicate that the consumption of residential buildings is about 30% to 40% of the total energy resources in the world. They also cause 33% of carbon dioxide emissions. Hence, energy and its production in these buildings are crucially important, so most research has gone toward self-sufficient or zero-energy buildings (ZEBs) (Karunathilake, 2019).

Green Building in a futuristic form is known as ZEB. Green buildings, in general, are constructions that are meant to make better use of resources (such as energy, water, and materials) and sustainability (Shin, 2019).

The Building Research Foundation Environmental Assessment Methodology (BREEAM) was established in the United Kingdom in 1990, while Leadership in Energy and Environmental Design (LEED) was established in the United States in 1994 (Moran, 2020). Other prominent initiatives include Japan's Comprehensive Built Environment Efficiency Assessment System (CASBEE) (Cabeza, 2020), Germany's Deutsche Gesellschaft für nachhaltiges Bauen (DGNB) (Van den Heiligenberg, 2020), and Australia's Green Star System. By including material selection as part of the green building definition, green building considerations include energy use, water use, indoor environmental quality, material selection, insulation, and building site effect. From the literature, one of the first accepted interpretations of ZEBs is that proposed by Lund-Andersen et al (Elshik, 2012) which includes net-zero site energy, net-zero source energy, net-zero energy costs, and net-zero emissions. Zero energy buildings are known as residential or commercial buildings that improve energy efficiency, in addition to making a balance between the energy consumed and the energy generated by the building itself from renewable sources such as solar energy or wind energy. These buildings are connected to the regular electrical network as well where the surplus energy produced can be sold or used as an additional amount recovered when needed. The basic elements of zero energy buildings are isolation, window openings, heating and cooling systems, heating the water, smart energy management systems, and solar cells.

Zero energy buildings are also divided into two sub groups: as nearly zero energy building (NZEB) and net-zero energy building (NZEB). The main difference in the system is in zero energy buildings as any building or facility characterized by that its total energy consumption calculated for a certain time equals zero. As for nearly ZEB, the energy source is the energy of the building itself, in addition to connecting the building to the electrical network to compensate for the energy difference spent on the building.

BIM can improve the process of construction as well as enable the exploration of alternative methods for a good decision (Habib, 2017). It may be helpful in the facilitation of the review of results and approaches for the improvement of the building performance to be checked according to the indoor environmental quality and energy efficiency. One of the examples is using the BIM for the simulations of the building performance and day-lighting analyses (Kota et al., 2014) that is usually helpful for the building designers in quickly evaluating the options of the design. An additional example is the multi-component assessment of the energy of the apartment buildings and houses with the use of BIM-based parametric researches for the identification of the critical variables and optimization of the parameters of the design (Sadhu and Singh, 2019).

Through the integration of the BIM with the tools of the building simulation and approaches of the optimization, there is a possibility in achieving the optimization of the building performance and supporting the management and the visualization of the operational performance of the buildings (Gerish et al., 2017). In the case of the handling of the sourcing and production of a large data amount for performance analyses, the tools like the Dynamo may be utilized for the extraction of the basic building geometry and efficiency that is associated with the information from the BIM environment and convert those to appropriate format of data-interchange for building the tools of optimization and simulation which may result in highly increasing the capability of BIM-based performance analysis and optimizations.

(Yan and Damian, 2008) have performed research for the assessment of building information model implementation benefits and advantages. The goal has been the assessment of the BIM ratio in the engineering, architecture, construction, management companies of the UK, U.S., and other countries (Zhang et al., 2015). Companies that have not been utilizing BIM have also been questioned. The questionnaires of the barriers to the BIM implementation have been sent to academics and AEC (i.e. Architecture, Engineering, and Construction) industry practitioners. U.S. has been defined as the undisputed leader in the use of BIM. Other than the U.S., only a small number of the companies in the UK implement the technology of the BIM; studies of feasibility remain in the process. Nonetheless, the local government had reported that by the year 2016 all of the construction projects of the public sector have to be performed with the use of the 2nd competence level of the BIM (Lin et al., 2016). 23 respondents (out of the 67 individuals that have been questioned) were from the U.S., 21 were from the UK, and 23 individuals were from other countries (Zuo et al., 2015). 25% of the respondents in the U.S. and UK have stated that the most significant benefit of BIM is the short time of designing. 25% of the respondents in the UK considered that it reduced human resources and costs. Over 10% of the respondents from those two countries believed that the benefits of BIM technology have been: sustainability, creativity, and better quality.

The national authorities, representatives of industry, and local governments in Finland started appreciating the opportunities, following the implementation of the BIM (Tulenheimo, 2015). The guide of the general BIM requirements, which has been published in 2012, has focused on increasing needs for the development of the standardized BIM and general rules. The initial requirements and mandates have only been for the designs of the buildings, however, in 2015, generalized infrastructure project requirements have been issued (Bradley et al.,2016). In numerous countries worldwide, one can observe BIM use promotion at the governmental levels (Petri et al., 2017).

The advantages of the BIM within the life-cycle of the building have been characterized by processes based on the guide-lines of the “Digital Construction" for 2014–2020 (Guidelines for Digital Construction in Lithuania 2014–2020). By the construction organizations in Lithuania: enhanced new spatial planning and designs, more rational decisions, and the smaller number of the mistakes. With the higher quality and more rational design process, there is a less necessity for the amendment in the future (Cereška et al., 2016). The model of the BIM visualizes design solutions of all of the parts of the design, for clients to gain more understanding about results, removing the mistakes that result from overlapping project parts (Ksi et al.,2015). Based on (Cid et al., 2015) theory, various BIM use scenarios show the BIM network to be sufficient in the reduction of the number of mistakes. The mechanism of mistake resistance: direct and permanent communications (in real-time), automated scrutiny of codes/standards, accident detection, continuous learning, and design versatility have been defined as compelling reasons that reduce the number of design defects. However, more researches are required for the verification of theoretical researches that has been performed by researchers. Nonetheless, they have discovered that they require time for training on BIM. It means that they require funding for training and facilities. This problem may be solved since the benefits of the use of BIM outweighs the drawbacks. In addition, in the case where workers get training only once, they will be experts and will not require an extra training in the future.

Throughout the years, the modeling software was upgraded with various modules to handle the structural design, analyses of the reinforced concrete, problems related to energy and environment, mechanical design, facility management, visualization, technical and product information for the distributors and manufacturers.

Nowadays, some utilize external applications where interoperability is usually enabled by statistical work with data export and import synchronizing multiple formats of data to launch work between modeling software and other applications dynamically. All is done while taking into consideration a significant issue of the management of projects with the use of the BIM. The plans of scheduling for construction objects usually signify a result of the common work of various experts. They can incorporate to schedules different information concerning project activities launching, assignment of workers, application of materials, employment of machinery, etc.

Conventionally utilized software for the scheduling of the project includes computer applications like the MS Project, Micro Planner, Primavera, Planisware, Teamwork, Super Project, X-Pert. However, the fundamental objective of BIM is combining the 3-D building models with the scheduling data for the production of the 4-D models where time is the 4th dimension. Results can include a construction launching animation in addition to scheduling data that is connected to a 3-D model. Nevertheless, a precise estimation and planning of the actual costs of the project are highly significant as well for the success in the business of construction. Handling project cost data with the use of the BIM method provide the opportunity for the more efficient management of the costs of the construction project. Right after the costs of the construction have been identified and connected to the elements of the construction and the scheduling data, the 5-D building information model is produced.

A study was conducted by (Pučko and colleagues, 2014), the aim of the study has been to give information about the time of the construction project and cost planning process with the use of the BIM method. This is why the time and cost planning steps of a construction project that employs the BIM have been presented. One of the examples that are based upon the Vico Office R4 software application has been given in the study for demonstrating the suggested method benefits where the initial phases of the design are carried out to be incorporated in the application of the BIM, architects must develop a 3-D building model and for the determination of the needed jobs. Nonetheless, the work of the design should not be carried out through the classical 2-D drawings. However, the 3-D model of the object of the construction has to be created as based on the material and geometrical characteristics of the elements of a building.

The setup of the geometrical properties of the building elements yields fundamental quantities like the object surface area, side length, and object volume. This is why the 3-D building model may be modified in a user-friendly way throughout the process of the design because the fundamental amounts will be updated automatically. Following the completion of the architectural design, engineers are capable of upgrading the 3-D model with much different information that is associated with the structural design and analyses, energy and environmental issues, HVAC, facility management, visualizations, technical and product information for the distributors and the manufacturers. Right after the completion of the 3-D model of the construction object, contractors have the ability to count the time and the efforts given. In the case where the model of the building has been upgraded with proper input data, contractors can obtain, in every moment, for every one of the building elements, all of the relevant information for launching works. This construction object model may contain information concerning the building elements types, the number of items, the geometrical amounts, launching times of project activities, resources that are required for the implementation, costs, technology implementation, etc. The most significant BIM benefit is that information about the object of the construction is stored in one place and kept updated. This is why using modern software allowing the BIM in the projects of the construction represents technological progress with numerous benefits for all of the participants. Thereby, the present study has been intended towards providing new valuable information for the experts of the construction management. In addition to playing the role of the basis for additional researches in the area of BIM-based construction project management (Pucko et al., 2014).

Another study about take-offs and cost estimation was carried out to examine the impact of the implementation of BIM in projects. Take-off itself may be characterized as the process that is used for the calculation of the amount, installation method type of all of the elements in an object, made before the process of the construction (Issa and Shen, 2010). In a conventional designing way, it has been found as a labour-intensive and time-consuming process, which has a susceptibility to human errors. Whereas the programs of the take-off have been available before the availability of the BIM technology. They offer only a less time-consuming a manner for counting the material amount and remains to require mostly manual input (Issa & Shen, 2010). The technology of the BIM has introduced numerous enhancements in the actual process of take-off, as well as in the sharing of the information concerning the elements and the installation of those elements in constructions. The elements may contain more information concerning every one of the elements, in addition, to which they may be divided in the way they will be installed. Information may be automatically processed for creating a take-off table. The design software in the technology of the BIM (in other words, Revit) has typically integrated options for the modelled elements take-off. Nonetheless, the scope of the possibilities and the displayed information differ for every one of the design programs. There are additional BIM programs as well for the take-off (such as the Vico Takeoff

Manager), besides the BIM programs of cost-estimation (such as Zuzia BIM) with these functions, typically with more possibilities for the modification and collection of data.

It has to be taken into consideration that the programs have different ways to display and read the data from BIM models that may result in the programs that display the data differently or not display it whatsoever. Automation results in speeding up the process of making take-off and results in fewer mistakes and omissions that result from the oversights in human factors. However, the use of the BIM tools results in the creation of new issues, like the fact that the data that pertains to take-off has to be input throughout the stage of the design. It needs close collaboration between takeoff makers and designers at each one of the design work stages (Kulaskara and Olatunji , 2013). It has been pointed out as well that the take-offs that have been compiled automatically do not exhibit the utilized amounts of the materials. Moreover, the amounts of the materials that have been included in the 3-D model. It also does not show the materials that have not been included in this model. To sum up, the tools of the BIM present take-off making process automation, speeding this process up and reducing the risks of the miscalculations and omissions that result due to human errors. It may include as well additional information that is necessary for cost estimates and take-offs, like the order of the assembly. The effective utilization of the tools of the BIM requires a model of set detailing degree with the information and descriptions included in a compatible way with take-off.

The cost-estimation process is highly associated with take-off – a well-prepared take-off may result in making the cost-estimation less labour-intensive, faster, and less prone to omissions as a result of human errors. A well-prepared take-off is crucial for cost estimation, as with no accurately detailed record of elements that require being priced, the evaluation of the cost will not be complete. In the conventional design work, the precise cost estimation can only be possible following completing documentation in the case where there are precise amounts of labour. Then, at the stage of the concept and throughout the process of the designing, the cost is calculated according to the earlier experiences with similar buildings, or set rates for a square meter of the similar or identical type of construction. Rates have been computed for the standard constructions. Whereas, there are ways for modifying the rates for suiting a certain construction, it becomes complicated obtaining adequate accuracy. This is especially noticeable when atypical constructions are built with innovative technology. Utilizing BIM gives more opportunities for increasing the accuracy and details of the cost estimation. In the conceptual stage, the model becomes more detailed compared to the cases of the conventional process of the design, because it has been a base for future changes (Herngunsel, 2011). It has allowed to make a more accurate and detailed cost estimation at this stage.

In addition, take-off process automation has resulted in enabling faster analysis of construction variants and costs. Like take-off, automation is the fundamental advantage of the BIM-aided cost estimates. Rather than the need for manual input of all information, the tools of the BIM result in creating a spreadsheet that is correspondingly structured to the elements of the construction, including automatic or semi-automatic take-off. Also, the main issue with the use of the tools of the BIM for the estimations of cost is the fact that automation can only be possible in the case where the model has been created based on the standards that have been set by the cost-estimator and correspond to programs that have been utilized for the estimation of the costs. Without this, automation can provide inaccurate values, or it might not be possible to obtain the cost. Even in the case where the estimation of the cost is computed based on a well-prepared model, it needs much work from the estimator of the cost. The automation concerns materials as well as their amounts which have been modelled in the design – it includes no additional labour nor materials. In Poland, those elements have been often taken from the National Contractor’s Estimator (KNR). The design programs like the Tekla Structures or Autodesk Revit have tools for the fundamental cost estimation based on automatic take-off; nonetheless, the tools do not allow for any more positions. More complicated estimates of the cost may be performed in the add-ons for the programs of the design, or in the cost estimating software of the BIM like the CostX BIM. The most popular cost estimation program in Poland is the BIM estimate. In summary, the cost estimation in the BIM has been strictly associated with the takeoff and mostly shares the same benefits and drawbacks. It results in higher automation of the process, but only in a well-prepared BIM model case (Salamak & Gołaszewska, 2017).

1.4 Hypothesis

In the research, a primary school building model in Iraq was relied upon as a case study. The energy cost in the building was calculated in the normal state. Then, the building was analyzed after drawing it and modeling the building information completely using building information modeling programs and concluding the results after the analysis to convert an existing building into ZEB. The extraction of several scenarios for reducing the energy in the building, as shown below:

(Windows glasses, wall construction, roof construction, lighting efficiency, day lighting, occupancy control, plug load efficiency, HVAC system, PV panel efficiency, PV payback limit, PV surface coverage and operation schedule).

After obtaining the expected scenarios to reduce the energy in the building, the cost difference was calculated for each of the above-mentioned paragraphs. Finally, arriving at the total cost was reduced using each of the above paragraphs.

2. INTEGRATION DATA

Recently, there was an increase in the attention towards Zero Energy Buildings (ZEBs), till many nations adopted such a concept as a part of their energy policy. The EU Directive on Energy Performance of Buildings (EPBD) stated that all new buildings will be “almost ZBEs” by the end of 2020 (EPBD recast, Directive 2010/31/EU). The major objective of the Building Technologies Program of the US Department of Energy (DOE) is to achieve “marketable zero energy homes in 2020 and commercial ZEBs by 2025” (US DOE).

2.1 ZEB

It is agreed that there is no universal and specific NZEB definition, yet, the major concept of using renewable technologies to decrease the requirements of energy and supplementing the remaining energy is agreed generally within design and academia fields. One of the major risks occurring due to such lack of definition is the over-engineering of buildings. Thus, the energy requirements will be oversupplied and ineffective (Sartori et al, 2010). They identified that the standards of energy performance concerning the comfort level made available via buildings and assumed the coexistence of such factors for NZEB. Besides, there has been a major concentration on the significance of buildings characterization via a climate zone and realizing that cooler zone-NZEB is considerably different from warmer zone-NZEB, assuming that energy usage is generally dominated via cooling and heating (Jagemar et al. 2011). A study conducted by (Sartori et al, 2010) reported that even though the definitions and models of NZEB must have consistency concerning their objectives, each one of the NZEBs must be customized for maximizing efficiencies based on locational factors, like climate.

Even though, being encouraged via the NZEB industry growth, a study conducted (Verma and Singh, 2014) assumed that NZEBs will continue to have limited legitimate examples due to the lack of robust definition of NZEB and standardizations in its practices. Therefore, NZEB examples remain sparse with an absence of evaluation techniques and well-established definitions, the cost efficiency of NZEB is still complicated to evaluate (Aelenei et al., 2013). However, their feasibility is still debated, NZEBs should be considered as standard building alternatives because of some problems like an increase in the demands of energy with growing usage and population, reducing non-renewable resources of energy, increased costs of energy,and issues of climate changes.

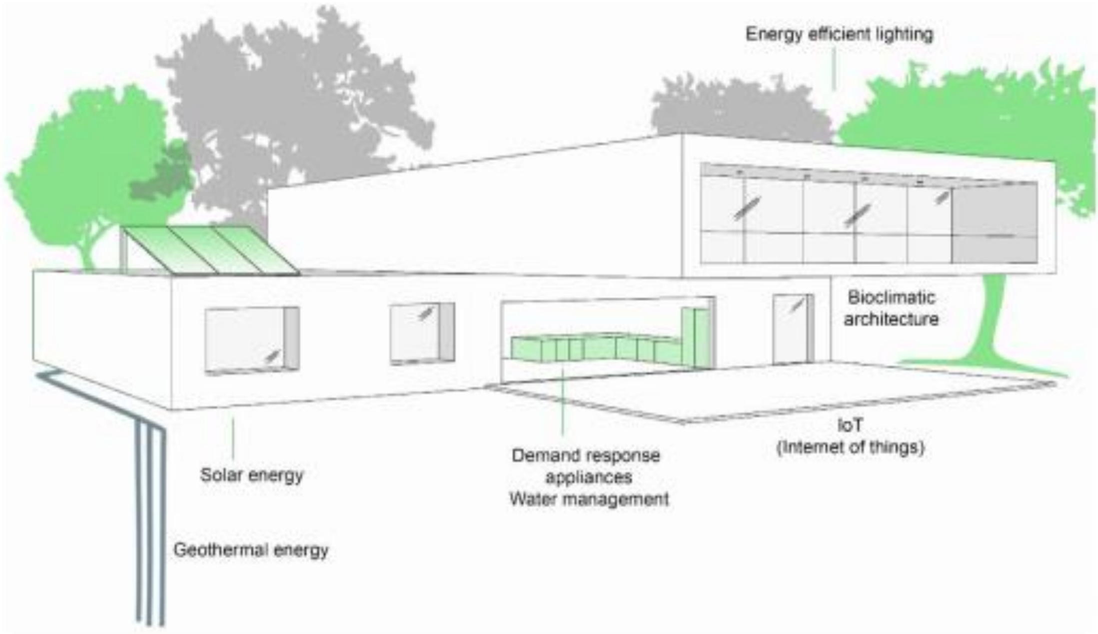


Figure 2.1: The Concept of ZEBs.

Source: (Luisa F et al,2020)

A total of 40% regarding the energy used all over the world is caused by the energy consumption in buildings, while considerable energy savings might be yielded via the changes and measures in building modus operandi. Today, it is expected that buildings should meet more complex and higher performance levels. They must be comfortable, sustainable, healthy, grid-friendly, use zero-net energy, yet cost-effective to maintain and build (Kolokotsa et al, 2011).

Figure.2.2 displays that in residential homes, the main energy consumption is due to Electric Boilers/ Heating Systems (18.7%) utilized for Hot water and Space Heating.

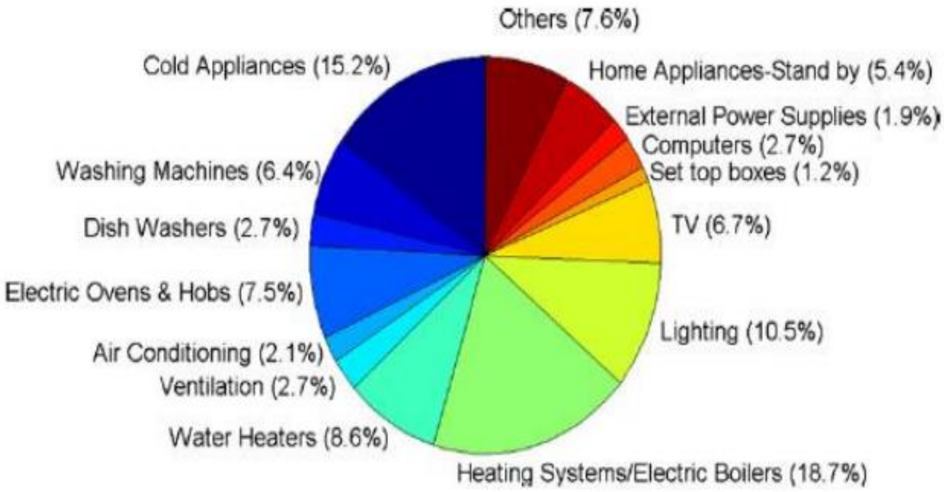


Figure 2.2: Breakdown of EU Residential Electricity Consumption, 2007

Source: (Ferrantea et al, 2011)

Buildings that are neutral over a year are referred to as ZEBs indicating that the energy supplied by them to the supply grids is as much as what they use from grids. In these terms, it might be seen that they do not require fossil fuel for lighting, cooling, heating, or other uses of energy. Energy might be often drawn by them from the grid (Sridharan, 2016). The concept of ZEB is not seen as a remote future concept anymore yet as one of the actual solutions for CO2 emissions mitigation and/or the energy use reduction in the sector of buildings (Anna et al. 2011). ZEBs are energy-efficient buildings by which electricity or other carriers of energy can be generated from renewable sources for compensating for the energy demands. Buildings connected to energy infrastructure are termed as Net ZEB, whereas ZEB is considered to be more wide-ranging and involves autonomous buildings.

'Net' indicates that the energy taken from and supplied back to energy grids has a balance between them over a while, supposedly one year. In NZEB, the aim is not just to use passive design approaches to reduce the building energy consumption. Yet, also to design buildings which balance the requirements of energy with active energy production methods and renewable technologies (for instance, BIPV, wind turbines, or solar thermal). The operation of NZEBs necessitates communications between various elements and systems of various types and serves different purposes as can be seen in Figure 2.3.

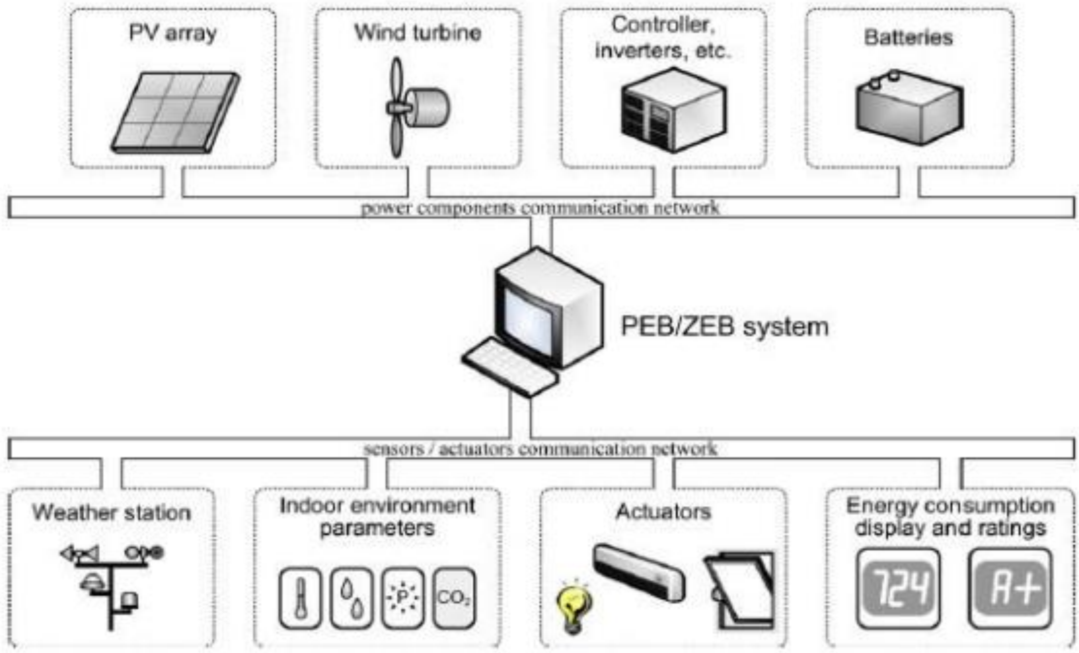


Figure 2.3: The infrastructure and monitoring of the ZEB/PEB system

Source: (Kolokotsa et al,2011)

Due to the many environmental problems caused by the building sector all over the world, the 1990 witnessed the introduction of the "green building" concept (Zhao and Zuo, 2014). Yet, various problems are hindering green building development today (Tan and Hwang, 2012). A major obstacle is the absence of integrated tools for considering multiple aspects of green buildings from the early stages of the project for optimal decision making (Belloni and Häkkinen, 2011). Building Information Modeling (BIM), as one of the developing technologies, is one of the main methods for addressing such issues. Design optimization and Integrated Project Delivery (IPD), for instance, it might be achieved to produce green building designs using BIM (Fan and Wong, 2013).

The terms "high-performance buildings" and "green buildings" were used interchangeably (Zhao and Zuo, 2014). The Energy Independence and Security Act (NIBS, 2011) states that high-performance buildings involve the integration and optimization of all the main building performance attributes on a life-cycle basis. These include cost benefits, operational considerations, and occupant productivity along with environmental sustainability (conservation of energy). Therefore, the integration and optimization of various building systems are vital to high-performance buildings. For the high-performance buildings to be achieved, BIM might be heavily and significantly involved to generate building model iterations for optimum design decisions and improving interactions between the team members of the project in the design process (Zhou and Wong, 2015).

2.2 BIM

BIM is assumed as a collaborative working process that supports Virtual Design and Construction (VDC) via using digital models. VDC can enhance productivity, business performance and streamline project delivery workflow all over the entire life-cycle regarding the building assets (SMACNA, 2017; WEF, 2018). Nowadays, BIM is considerably developed in many cities and nations. Also, it is one of the main determining factors for the digital transformation as well as the improvement of the construction sector (Hui, 2018). Recently, various literature and researches examined the BIM role in sustainable construction; exponential growth was registered by the relevant publications on such subject (Santos, et al., 2019). In addition, it is assumed that in BIM, environmental sustainability can be improved via a “green dimension” throughout the life cycle of the building (Wei and Bonenberg, 2015; Zhou and Wong, 2015).

Green BIM is a term that means using BIM for providing data for sustainability assessment and energy performance evaluation (Maltese, et al., 2017; Lu, et al., 2017). The fundamental concepts of Green BIM are shown in Figure 4. Typically, Green BIM involves building energy modelling which deals with project energy performance to recognize options and optimize building energy efficiency throughout the life cycle. However, BIM might offer a decision-support basis to evaluate key carbon emission sources for achieving holistic designs as well as evaluation of low-carbon buildings (Gan, et al., 2018). Furthermore, a BIM-based technique for green buildings might allow professionals to predict the construction outcomes for minimizing the effects on the environment during its life cycle as shown in figure 2.4 below:

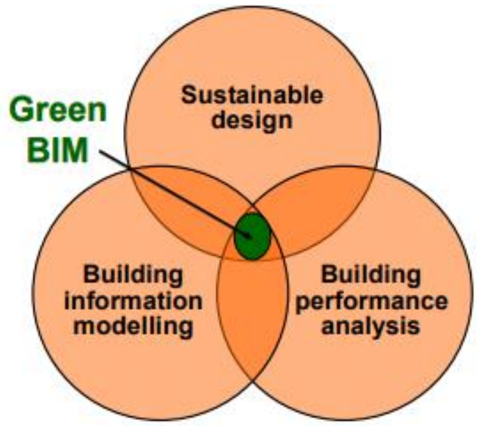


Figure 2.4: Basic Green BIM Concepts

Source: (Ir Dr. Sam C. M. Hui, 2019).

The construction project is simulated by such digital models in a virtual environment and might utilize for the construction, design, operation, and planning of the facility. BIM might be utilized for improved documentation, visualization, conflict detection, collision and interference, structural analysis and building performance, construction sequencing, code reviews, automated assembly and prefabrication, facility management, and cost estimating (Azhar, 2011). Moreover, the model of BIM is considered as one of the shared knowledge resources for information about a facility; creating a dependable base for decisions throughout its life cycle. The BIM applications at various phases of the project life-cycle are shown in Figure 2.5.

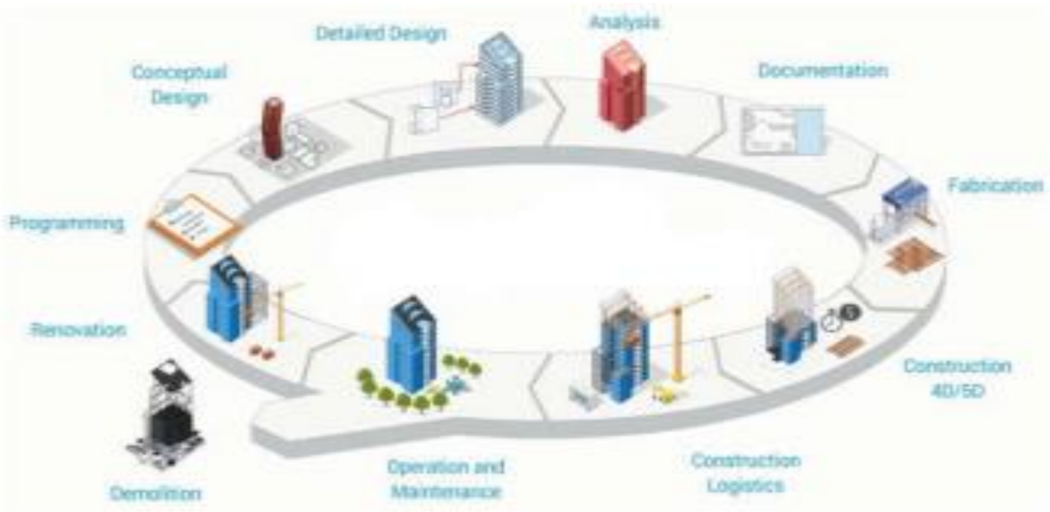


Figure 2.5: BIM At Various Phases of Project Life-Cycle (Autodesk)

BIM can be defined as a process of; (a) developing holistic and integrated a strategy of creating buildings that involve construction, design, and life cycle management based on computer simulation and modelling (Paavola and Miettinen, 2014). (b)

Utilization and creation regarding a system of information flow and integrated graphical data management concerning the construction process description. (c) Turn single contractions into teams working like decentralized units which handle complicated issues and integrate separate tasks into coherent processes. Therefore, it is expected to have an increase in effectiveness and costs reduction in many operations during the whole building life-cycle (Peter et al., 2014).

Based on the applications of PLM (Product Lifecycle Management) to building, traditional 3D BIM is turned into 4D,5D, 6D, or even 7D, and, in the future, 8D versions... The solution is termed unified project management or BLM (Building Lifecycle Management). Beside, such a trend occurs due to using large amounts of information provided in smart 3-D building models. Figure 2.6 shows the synthesis related to aspects integrated into the framework of BIM.as shown in figure 2.6 below:

Figure 2.6: BIM Lifecycle View

Source: (Marius Reizgevičius et al, 2018)

The dimensions of BIM beyond the 3rd one is (Mirzaei et al., 2018)

- 4D-virtual model of the developed structure with work progress control and construction plans; with greater capacity for picturing (prospectively) a building that is virtually constructed at any given time.

- In addition to the building timetable, 5D cost data is input into a 3-D model. The benefits of 5D BIM may include increased precision and predictability of project modifications, as well as more reliable cost analysis for diverse construction scenarios.
- 6D-introduction into the investment process of the idea of sustainable development, with a focus on energy efficiency. BIM 6D enables the acquisition of information about a building estimated energy usage at an exceedingly early (concept) stage.
- 7D-integration of the Facility Management concept into BIM. It allows to keep track of the state of particular building components as well as their warranty durations and specifications. From the demolition concept, 7D-BIM involves managing the entire building's life cycle.
- 8D- -adding healthcare and security information to the model. 8D focuses on three tasks: signalling the need to control particular risks on the job site, providing alternatives to the riskiest options, and recognizing the hazards posed by specific construction and design solutions.

The methodology of BIM is essential in the digital transformation of the built environment and construction sector. Globally, and especially in Europe, public promoters and governments might identify the BIM value as one of the strategic factors for environmental, cost, and social quality, also value in developing competitiveness and growth policies in the sector (Hermoso-Orzáez et al., 2019). Proactive steps are taken by many in terms of using BIM in the construction, operation taking into consideration environmental and economical advantages.

The methodology of BIM involves the monitoring, direction, and control of the project as well as managing all the generated information during the project development; such as the initial stages of planning, alternatives selection, and conceptual design, procurements from suppliers, development of most-advanced stages which involve facilities and structural design (Guerrero and Lindblad, 2020). Of course, without forgetting that the control or monitoring and the management of constructions and future maintenance of facilities, 4D, 5D, 6D, and 7D stages are essential aspects (Charef et al., 2018), like energy efficiency (Habibi et al., 2020), sustainability and functional safety of buildings and infrastructure, the second and third are vital, as can be seen in Table 2.1 (Mirzaei et al., 2018).

Table 2.1: Aspects, Properties, and Dimensions to Be Established in the BIM Model For Buildings

Dimensions BIM	Properties	Aspects Developed in the Model
2D	2D Basic Docunentation	Traditional two-dimensional (2D)plans Lines,plaers images
3D	3D three -dimensional	Graphic documentation in three dimensions (3D) special geometric information objects with properties 3D visualization of the project
4D	Programming the Execution plan (Deadlines)	Simulation of project phases installations simulation design of the execution plan
5D	Planning,monitoring and cost control	Budget estimate of expenses measurements of materials and laber analysis of operating costs
6D	Sustainability and energy efficiency	Energy analysis Envelope variation and intractions analysis of sinulation and energy efficient and environmentally sustainable proposals
7D	Facility Management	BIM life cycle analysis (LCA) stratiges BIM as built Building operation and mentainance plan model Logictical control of the project

Source: (Mirzaei et al., 2018)

Designing low-energy buildings necessitates dynamic simulations for analysing multiple scenarios and achieving optimal solutions; generic algorithms and multi-objective optimization are the most prevalent now (Zemero et al., 18). The previous studies indicated that the major examined objective functions are costs as well as operating energy consumption, whereas the environmental aspects are commonly ignored (Carreras et al., 19). Within the optimization, the selected parameters reliability is vital to achieving the anticipated energy efficiency (Peruzzi et al, 2014).

The presented work focuses on the buildings sustainability (the best choice for that is 6D BIM). It has been modelled to hand over procedure and developed to be a guide with all the required information provided dynamically. It organizes the building smooth functioning, as well as planning measures for renovations and maintenance, works throughout the whole building lifetime. In 6d BIM, one of the major advantages is the simplicity in accessing the database of building elements by which the information concerning the model, producer and type of equipment, technical specifications, and service intervals might be evaluated at any time. In such an approach, the supplements and information are easily managed via the building manager, whereas the information material is received in conventional facility management, including instructions maintenance and operation, as-built drawings, completion certificates are of static significance (Pučko et al., 2017).

The visualization of BIM helps streamline projects reduce obstacles and inform decisions via bringing to life the components and projects before they begin and are being developed. Generally, in common building projects, many critical functions are served via architectural visualization for conveying aesthetics, function, mass, and meaning regarding the final or conceptual design, concerning the requirements of the owner and intent for the new structure. In addition, when integrated with schedule and time, the 4D sequencing process is enabled via BIM to allow discovering possible schedule enhancements and improve construction operations via the project team. Today, advanced visualization approaches and 3D BIM technology might function hand-in-hand for generating performance models and complete pictures for building energy analysis, day-lighting simulation, construction execution and planning, also energy conservation, and facilities maintenance. Photo realistic images, computer graphics, animation, fly-/walk-through the models might be utilized for improving the understanding in various analysis, presentation and design tasks. An example of BIM-supported day-light analysis and visualization is shown in Figure 2.7. The location of a PV system and the orientation of the building might be determined via a comprehensive BIM solar shading analysis (Hui 2019).

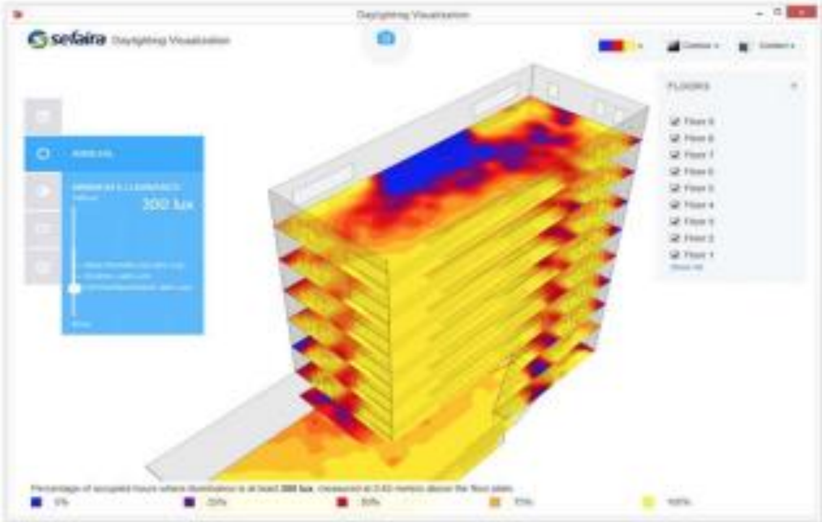


Figure 2.7: BIM-Supported Daylight Visualization and Analysis

Source: (Ir Dr. Sam C. M. Hui,2019).

Visual communication and representation might be enhanced via BIM-based visualization which acts as one of the efficient tools for collaboration. The project team is assisted via the building realistic BIM model to communicate vital updates straightforwardly and promptly when needed. Also, construction managers are allowed via a well-constructed model of BIM to conduct many alternative plans for visualizing the whole project planned sequence. Clients and other stakeholders might be subsequently sharing the visual representation which could act as a base for more actions. Due to the increase in innovations of virtual prototyping and visualization technologies, like immersive visualization, augmented reality (AR), virtual reality (VR), and mixed reality (MR), it is anticipated that real-time BIM visualization and intelligent 3D modelling might be utilized more efficiently for empowering BIM-based decision-making process. Lately, the partnerships between BIM as well as vendors of visualization software (like Unity and Autodesk; Twinmotion and Graphisoft) have offered a few indications on upcoming visualization power in terms of BIM applications. Furthermore, the integration of GIS and BIM, at macro-level representation, might provide visualization in addition to analysis of structures concerning built and natural environment (Luo, Pan, and Wang, 2019).

2.2.1 BIM software tools for energy simulations to realise a ZEB

There are many tools used by BIM to perform an energy simulation. Table 2.2 shows examples of energy analysis using BIM tools.

Table 2.2: Using BIM tools Examples

YEAR	TITLE	TOOLS	RESULT
2016	A Study on the LEED Energy Simulation Process Using BIM	The architectural geometry modeled through the BIM tool is converted to the gbXML, and in this process the geometry is verified through the interference check functions, the gbXML Viewer and the FZKViewer	In reviewing the functionality of the Revit gbXML Viewer program, we made use of the FZKViewer. Since both programs act only as object viewers, a major drawback is that visual verification of errors requires some effort. Moreover, when an error is detected, it is another problem to find and repair the object again
2020	Sustainability and Energy Efficiency: BIM 6D. Study of the BIM Methodology Applied to Hospital Buildings. Value of Interior Lighting and Daylight in Energy Simulation	Daylight simulation. 3D view of the illuminance analysis in REVIT INSIGHT	the software used allowed the calculation of two criteria of LEED certification, which made it possible to verify the state of the BIM model. Considering that the building is 50 years old, the results were not as far from the standards LEED as one might expect. If the building's blinds were automated, a better correlation would be obtained. This simulation of natural light should be an objective method for evaluating prices when awarding public works contracts.

Table 2.2: (Cont.) Using BIM tools Examples

YEAR	TITLE	TOOLS	RESULT
2016	Opening performance simulation in nutural ventilation using Design Builder	Using Design Builder version 4.5 wind simulation using CFD model	This tool help to explain the wind behavior in the room so that will effect to the dimentions of the windows in the building ,thermal capacity of wall and material
2018	Using BIM to simulate the Energy Consumption and reduce its cost	Green building studio 2017	The results show that the impact on energy reduction is greater when the ceiling tiles are installed in the building and the reduction is almost 20%, the type of wall is next in frequency of more than 10%, and the third is the type of windows, the single glazed glass has an impact of 7% on energy consumption.

2.3 General Analysis

Figure 2.8 shows the focus on various Building Performance Analysis (BPA) types in the collected papers on green BIM. Thermal and energy analysis (T&EA) are the most discussed analysis types, as can be seen in Figure 2.8. LEED rating analysis (LEED) and Green Building Rating Analysis (GBRA) comprise the 2nd tier. Also, some of the other significant topics of research are Carbon Footprint Analysis (CFA) and Cost-Benefit Analysis (CBA). Although, the significance of water resource and indoor environmental quality was very recognized, researches on BIM in terms of acoustic, ventilation, and water efficiency analysis are infrequent; these are vital topics to be studied in the future.

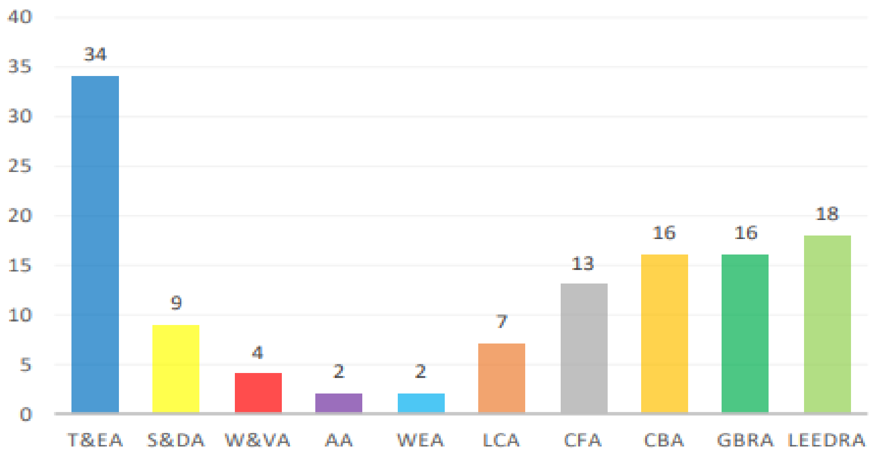


Figure 2.8: Green BIM Research by Building Performance Analysis (BPA) Types.

Source: (Yun-Tsui Chang, 2020)

BIM can be defined as the process of the creation of a 3D design platform, allowing architects and engineering consultants to play a role in the process of the design on a real-time, multi-discipline basis. A very important function of BIM is its capability in improving coordination between several of the design disciplines, thereby resulting in the reduction of errors. It has been believed that BIM might provide the ability for a data-driven method for construction, building planning, and maintenance (El-Diraby et al., 2017). In the case where everything is connected via the BIM for the management of interactions, it can improve the issue/project management, in addition to the construction/design coordination. To achieve total integration and effective collaboration, one of the alternative ways of thinking and a different method for the projection of the delivery and procurement are necessary. With the use of BIM-based collaboration in an integrated system of the design, it can enhance productivity and design quality with the use of the necessary support for the collaborative design.

2.4 Green Building Analysis

The variety of the BIM advantages like the improved analysis, effective decision making, easier access to the information, and simpler green building evaluation present an enhanced solution for sustainable design and constructions (Yaman and Ilhan, 2016). With an integrated BIM-based process of the design, the required data for the assessment of the green building may be obtained from the BIM models for the calculation of green rating and the provision of feedback for additional evaluations. Moreover, the crucial documentation that is needed to obtain the green building certifications may be produced efficiently and timely. Sometimes, a BIM-based method may provide automatic evaluation and assessments of the building envelope design for the thermal efficiency according to calculations of the overall thermal transfer value (OTTV) (Natephra et al., 2018).

Generally speaking, the BIM can be helpful for the designers for the selection of the correct material type throughout the early stage of the design and for making important decisions, having great effects on sustainable building lifecycle (Jrade & Jalaei 2015). In the case of being associated with the rating systems of the green building (like the Green Mark and LEED), the BIM may be helpful for the automation of the process of the identification of the necessary number of the points, based upon the chosen categories of certification, accumulates total chosen points/credits and proposes a qualified type of certification within the platform of the BIM (Liu, *et al*., 2017; Jrade and Jalaei, 2015). Which results in facilitating BIM integration and assessment of sustainability.

3. ENERGY EFFICIENCY BUILDING

ZEB can be designed from the beginning. Ordinary buildings can also be converted into zero-energy buildings or close to that. Through the research, the focus is about converting existing buildings into zero-energy buildings. All this is done through the use of several methods to improve the performance of a given building.

3.1 BIM Integration with Sustainability

3.1.1 Building information modeling

Building information modeling: It is a numerical representation of the functional and physical features of an organization. It provides a common knowledge resource for the organization information and forms a reliable basis for decisions during the lifecycle of the organization from the initial concept even demolition.

3.1.2 Dimensions of sustainable development in building information modeling

3.1.2.1 Economic dimension

The economic value of BIM crystallizes in the triad of quality, cost and time. By improving the quality management and scheduling of project management activities, reducing the risk of project failure and project delivery timeliness, effective resource management, and improved cost estimation. Rapid cost forecasts are generated throughout the life cycle of a building when BIM is used for cost estimation.

Although, it requires cooperation between the design engineer and the launching engineer during the design of the digital model. BIM makes estimation simpler and more accurate and can provide estimates with more detail in less time and lower costs. In addition to the possibility of knowing the actual materials used in the implementation, software BIM can carry out the quantities and pricing processes required for cost estimation. In general, the accuracy of the cost estimate correlates positively with the amount of project information available.

3.1.2.2 Environmental dimension

BIM provides 3D LCA analysis for the entire construction process and provides a platform to manage and manipulate data. It also allows users to manipulate a three-dimensional building model and analyze interactively for environmental emissions. It also allows visualization and monitoring of carbon emissions during the period of operation of the building. When it comes to BIM ability to analyze life cycle impact analysis (LCIA), there are many softwares and applications offered by BIM in the context of environmental analysis

3.1.2.3 Social dimension

BIM may mean adding a sustainable social value. In termsof human life, it reduces site accidents and hazards, improves employee productivity and working conditions, and improves the quality of life and health for residents in the building. It also promotes a social justice and increases employment opportunities for participation and cooperation .

It is a platform for teamwork that enhances cooperation and coordination between project elements and enhances leadership and sustainabile strategy and supports effective communication and information sharing, in addition to supporting response processes.

BIM also enables improved security and safety plans during the construction operations; like, fire, emergency, external and internal environment analysis, improved study of humidity and thermal loads and internal ventilation.

3.1.3 Benefits offered by BIM. software

1. Calculates annual energy consumption and costs for making early compliance decisions and estimating costs using average interest rates or custom rates that can be applied to the project. It generates more breakdowns in the use of energy for electric and gas uses. The main items such as lighting, thermal heating, and space heating are in graphical forms, as well as providing additional detailed data associated with each category as a filter.
2. Analyzes every exterior surface of the building, including roofs, walls, and windows to determine their ability to generate electricity using solar panels (assuming the possibility of installing photovoltaic panels on vertical and

horizontal surfaces). It analyzes the annual amount of electricity that can be generated from various wind turbines diagonals.

3. Estimation of water use based on the number of people and the number of health devices in addition to the type of building and the type of sanitary equipment.
4. Calculation of annual working hours and expected energies used for ventilation and cooling buildings automatically, and the annual hours that can benefit from the outside air in the natural ventilation of buildings. Estimation of potential energy savings when HVAC equipment is not used.
5. Provides a summary of the amount of carbon emitted and identifies the options available to reduce it.
6. Provides a list of statistics and detailed information based on selected assumptions. It also allows building subscribers to get an early assessment of code matching and an approximate estimate of the size of fixtures required for heating, cooling, and water heating and the size of windows, walls and floor areas.

3.1.4 Tools for integrating building information modeling with sustainability

3.1.4.1 Autodesk revit

Energy analysis: It is the process of analyzing the performance of buildings by calculating how best to integrate form and systems. The scope of implementation of the building within the surrounding environmental conditions.

Revit Autodesk has many energy analysis features known as Building Performance Analysis clouds, which facilitate the possibility of obtaining LEED certification

Tables in Revit can be used to calculate different parameters related to materials (recycled content, recycling rate, water usage (equipment flow rates, rainwater harvesting area), location usage energy (heat island stimulus, design for rainstorms).

3.1.4.2 Tally

It is the first application that measures the environmental impact of building materials and allows a life cycle assessment (LCA) (the state of demand during the construction process). BIM tracks information about the eight classes of lifecycle stimuli defined by v4® LEED or systems other classification. Tally® enhances the user's ability to create a realistic bill of materials and provides an at-a-glance view of differentiations ecological choices for different design options by taking advantage of BIM capabilities to inventory materials, as well as its ability to waste management by promoting energy management, reduction, conservation, water management, and pollution reduction.

3.1.4.3 Green building studio

It is a simulation engine for total building energy analysis, offering a set of data related to the climate of the building site, the cost of operation, the amount of fuel required for operation. Energy analysis can be done for any file in gbxml format, and therefore any program can export its data in gbxml format. A work can be done by green building studio through Gbs, the results of energy simulation can be obtained in the form of diagrams such as intensity of energy use, energy life cycle, cost and utility, renewable energy capacity, annual carbon emissions, energy consumption, monthly heat loads, monthly cold loads, annual cost and use, energy consumed with fuel, monthly fuel expenditure, monthly electricity consumption, monthly maximum demand, annual wind rise, annual losses, daily weather, and humidity averages, and temperatures are all factors to consider.

In this research, the Revit program is used to draw the model that is analyzed in the Insight 360 program.

3.1.4.4 Insight 360 program

With advanced simulation engines and buildings, performance analysis data integrated into Revit. Insight helps architects and engineers to design more energy-efficient structures. It can be accessed through the Revit program in the analysis bar or on the internet at the Insight 360 website. It is a tool for comparing design options for a building model by analyzing the sensitivity to the average energy cost by a group of meters. Insight360 dashboard is an interactive work platform that allows the user to compare different design scenarios without modification to the actual Revit model. The figure at the bottom shows the Insight dashboard for the model of this research, and in the upper left corner of the model, there is a circle containing the result of the average energy cost of the building and in the first block of the second row gives a comparison benchmark that evaluates the building according to the 2030

Architecture indicators benchmarks 1.90 ASHRAE and for the energy model, and both the average cost of energy and the benchmark index change with any change in the other meters. The main goal is to reach the green color for each of them. The adjacent block history model is an interactive record of all the changes in the energy analysis. The rest of the blocks are interactive properties and ranges for energy analysis. Before modifying to any scale, the default model should be saved as the first scenario for comparison with changes. Care must be taken when adjusting the ranges. It is possible to obtain good results according to the index, but they are not realistic. For example, the lowest cost values can be reached when the ratio of the window is 0%, but this is not realistic.1.90 ASHRAE: The Energy Standard for Buildings Excluding Low-Rise Residential Buildings is an American National Standard created in collaboration with ASHRAE and funded by IES that establishes minimum requirements for the energy-efficient design of non-residential structures. Benchmarking is the process of comparing the measured performance of a device, process, or organization with itself, with its counterparts, or with specific standards, to identify and motivate performance improvement when applied in the field of energy use. Performance measurement works like a mechanism to measure the energy performance of a single building over time. Or, it can be considered as a typical simulation of a reference building based on a certain standard. 2030 Architecture is guiding the global engineering and construction community to adopt the following goals:

Designing new buildings and restoring old buildings to meet fuel, energy, and environmental emissions by 70% less than the local or regional average for the type of building. Working to ensure that the reduction rate in 2020 is 80% and in 2025 it is 90% to reach the neutralization of fossil fuels from consumption in the year 2030 AD and replace it with completely renewable energy sources.

Through the analysis the program, the following options are given to improve the performance of the building:

3.2 Window Wall Ratio

Window-to-wall ratio (WWR) which is also known as window area, is a vital variable that affects the energy usage and efficiency of a structure or building. The window to wall ratio affects the heating, cooling, and lighting of the building. It also plays an important role in the natural environment and access to daylight, ventilation in the building, and inner and outer views. It is calculated by the division of the total glass area of the building to the wall areas of the outer side or shell in terms of percentage area.

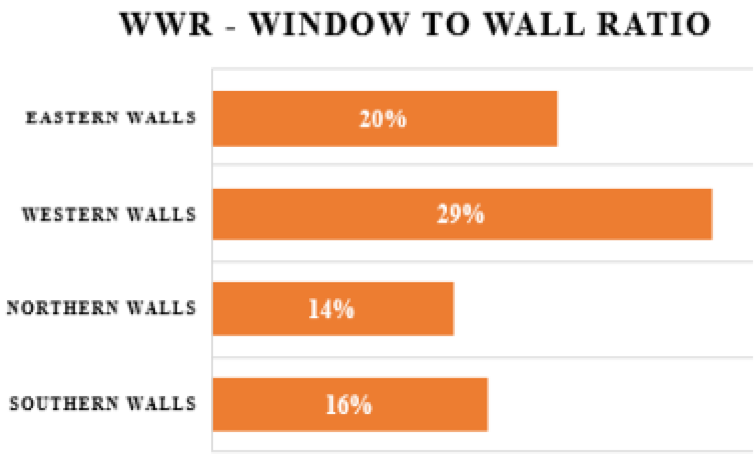


Figure 3.1: Effect of window-to-wall ratio on measured energy consumption

Source: (Irbaz Hasan, 2020).

3.3 Window Shades

Window shades can decrease energy utilization for heating and cooling due to solar radiation which depends on factors like solar properties in terms of heat gain and size of the window. Some portion of sun radiation is directly catch by the shade and reflected from the window. Some shades are partially transparent so the radiations directly pass through them. Heat absorbed by the shades is mainly carried away from the window by airborne convection currents or radiation.

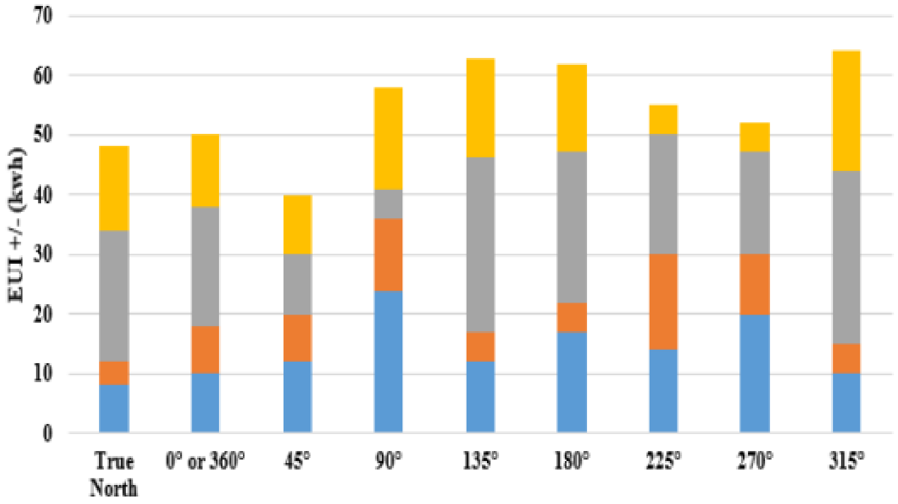


Figure 3.2: Windows Shades

Source: (Irbaz Hasan, 2020).

3.4 Window Glass

The amount of daylight that enters a building along with heat transfer and gain is controlled by the glass properties, along with additional factors. External Windows usually made up of glass that is a transparent glazing material used in the building envelope.

3.5 Wall Construction

In energy analysis, the purpose of wall construction is its strength and its overall ability for resistance towards heat gain and loss. In this case study, walls are made up of building blocks and plaster insulation and paint on them later on. Insulations in the wall significantly affect the internal environment of the building.

3.6 Roof Construction

In energy analysis, the purpose of roof construction is load-bearing and also its overall ability for resistance towards heat gain and loss. A typical reinforced cement concrete roof is used in this building. Insulations of roofs significantly affect the energy usage for heating and cooling.

3.7 Infiltration

The unintentional leaking of air into or out of conditioned spaces. Frequently, because of gaps in the structure or building insulation. Leakage of air mostly through the cracks or gaps in the building envelope as well as the windows or doors used for passage. Building Porosity and magnitude of wind as well as temperature are the major factors on which the rate of air infiltration mainly depends on.

3.8 Lighting Efficiency

The definition of lighting efficiency is a representation of the energy-saving properties of lighting appliances. The performance of LED light sources is measured by using its index value. It represents power or electricity usage of lighting and the internal heat gain per unit area.

3.9 Daylighting and Occupancy Control

This includes the advanced system used for automatic detection of the occupants with the help of sensors and dimming of daylight. Occupancy sensors automatically turn on and off lights to increase suitability, safety, long-term energy savings, and decrease fuel consumption. Daylight sensors worked with the help of the power provided by their batteries. They can save energy with the help of dimming and turning off the lights if there is enough daylight accessible. They also detect the light in the space and then adjust the lights to make the daylight better, thereby saving energy. Figure 3.3 illustrates that the value of energy-saving is increased as controls increased from no control to daylighting and occupancy control.

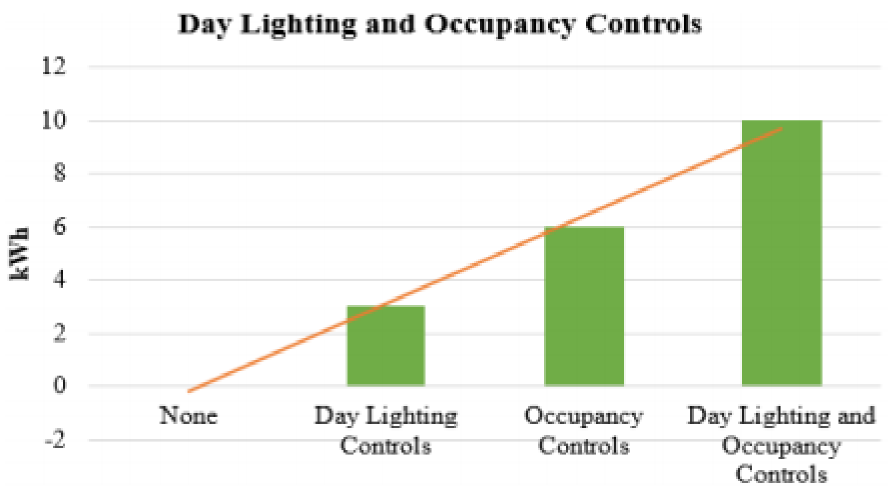


Figure 3.3: Daylighting and Occupancy Control

Source: (Irbaz Hasan, 2020).

3.10 Plug Load Efficiency

The plug load is the electricity or energy utilized by goods or appliances that gain power through plugs of electricity. Nowadays, commercial buildings have height plug loads which are rapidly rising with time. In offices, they account for 15-20% of the electricity consumption in the office. Lighting, heating, and cooling equipment are not included. 6.46 w/m2 is the plug load efficiency in this case study. This value is selected based on the most feasible values in the residential sector.

3.11 HVAC

The HVAC setup provides heating and cooling capacities for buildings. HVAC framework has become the requirement for the construction of new buildings nowadays. Different HVAC systems have different efficiency according to the type, location, and size of the building. Buildings have different HVAC systems according to needs. So, a range and its effect on total energy consumption are shown below.

3.12 Operating Schedule

It is the total utilization of energy consumption due to the building occupants' time spent in the building in terms of hours and days. In a residential building, energy consumption is random according to occupants' energy usage patterns. So, the average value is considered for optimization.

3.13 Photovoltaic Panel Efficiency

Photovoltaic panels are used to convert the energy from the sun radiation into electricity. The panel having higher costs are more efficient as it produces more energy by using the surface area. The efficiency of the panel is 14% in this case study. This value is selected from a given range because it gives the maximum energy savings.

3.14 Photovoltaic Surface Coverage

It is the total area that includes the whole system and is covered by the panels for the production of electricity or conversion of sunlight into energy in terms of electricity.

4. CASE STUDY: A PRIMARY SCHOOL BUILDING IN BAGHDAD

A primary school located in Baghdad, Iraq has been selected for a case study to prove the efficiency of photovoltaic panels in some countries that are being developed. The school was constructed in 40% using reinforced concrete (the super structure). The code used for the structural design is the American concrete institution code (A.C.I).

4.1 Properties of the School Buildings

The school consists of three parts as administrative building (one-story), classrooms (two-story), and W.C group (one-story).

The total floor area is about 2070 m^2 administrative building has approximately 358 m^2 floor area, which is shared as administration staff and teachers' room and a store. The Health group of the school is near to the administrative building,. The two-story part of the school is designed for 18 classrooms. This part has almost 1500 m^2 floor area for 2 stories, the area of WC space is about 212 m^2. The area of the upper roof is about 1320 m^2. The walls of the building are of regular bricks, with a net thickness of 25cm. The windows in the building are 120 * 150 cm wide, while the bathroom windows are 240* 150cm. They are made of aluminum.

4.2 Dynamic Energy Optimization with Revit and Insight

Several building analysis tools are available in Autodesk Revit. This demonstration will go through the fundamentals of performing a power simulation from within Revit. It will be shown how to use Revit to create a 3D energy model including an overview of the Autodesk Insight 360 Cloud Service, as well as an introduction to Revit new 3D power model rendering and Auto split feature.

4.3 Energy Simulations within Revit

When someone first starts using the energy simulation tools, they might be unsure where to start because there are so many options and commands.

1 Create a Revit model using masses, building elements, or both ,Revit model is found in building elements in the investigation of this research case study.

2 The Energy Options dialog box:

(Select a location – select the HVAC system, select the type of building, select the operation scheduel of the building) .

3 Examine the Energy Model Visually

4 Launch 360 Insight

4.4 Creat Revit Model

The first and most obvious step is to design the model. Starting with massing and immediately researching how shape and orientation affect performance would be the optimal design method. Revit building elements for known aspects of the design, such as curtainwall, windows, and sunshades, can be added to the mix as the project progresses. The mass elements are eventually dropped in favor of a more complex model made entirely of Revit building parts. Here are a few things to remember when creating Revit models.

4.4.1 Draw model

As Revit program consists of 3 parts:

1- Revit Archetectural
2- Revit Structural
3- Revit MEP

Since most of the school walls are from block, the Revit architectural model is used. Firstly, it is done through opening the Revit program and then choosing an architectural template to start drawing the architectural model, as shown in the figure below:

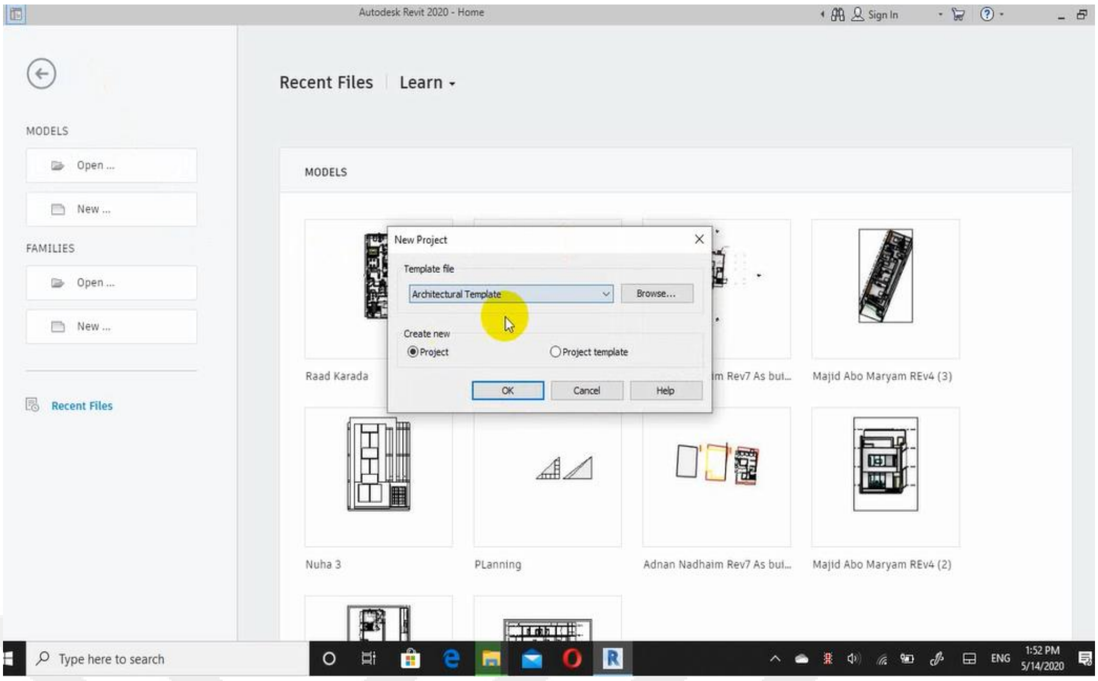


Figure 4.1: Select Template (Arcitictural Template)

Secondly, the number of floors is determined according to the architectural plans, drawing them as the Revit program gives only one level, as shown in the figure below:

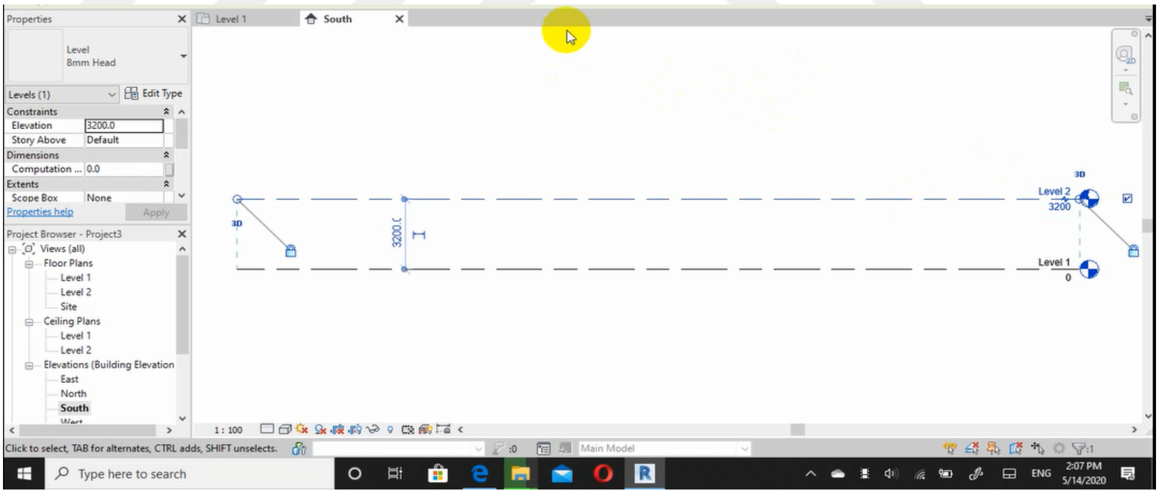


Figure 4.2: Grids and Levels for first floor

The plans are adjusted as the school building consists of two floors with a height of 3.2 m Per floor, where *Architectural* is selected then another Level is selected as shown in the picture below to add a new level.

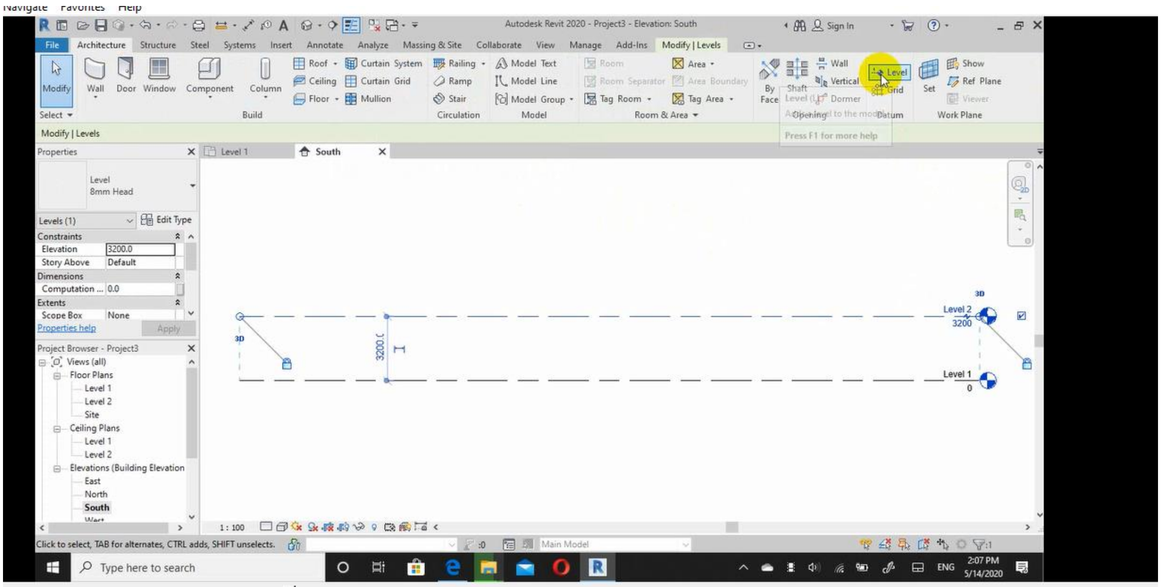


Figure 4.3: Grids and Levels for second floor

The level name can also be replaced with the floor number, each according to its height, as shown in the figure below:

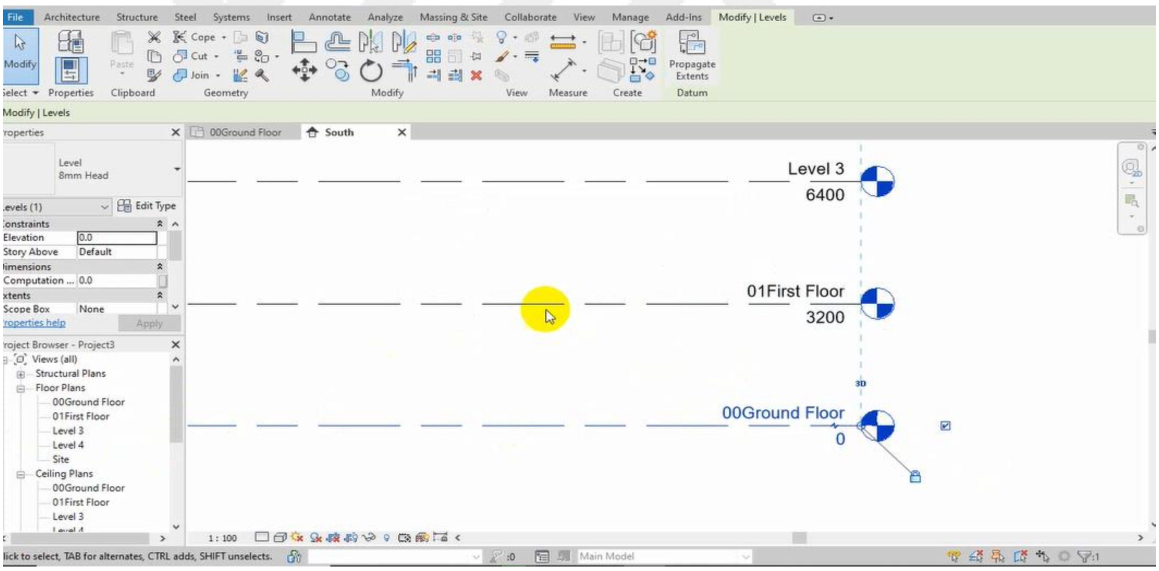


Figure 4.4: Levels & Names

Then, the plans are given to the program to be drawn in the Architectural Revit Program according to the location in which it is stored in the computer as shown in the figure below:

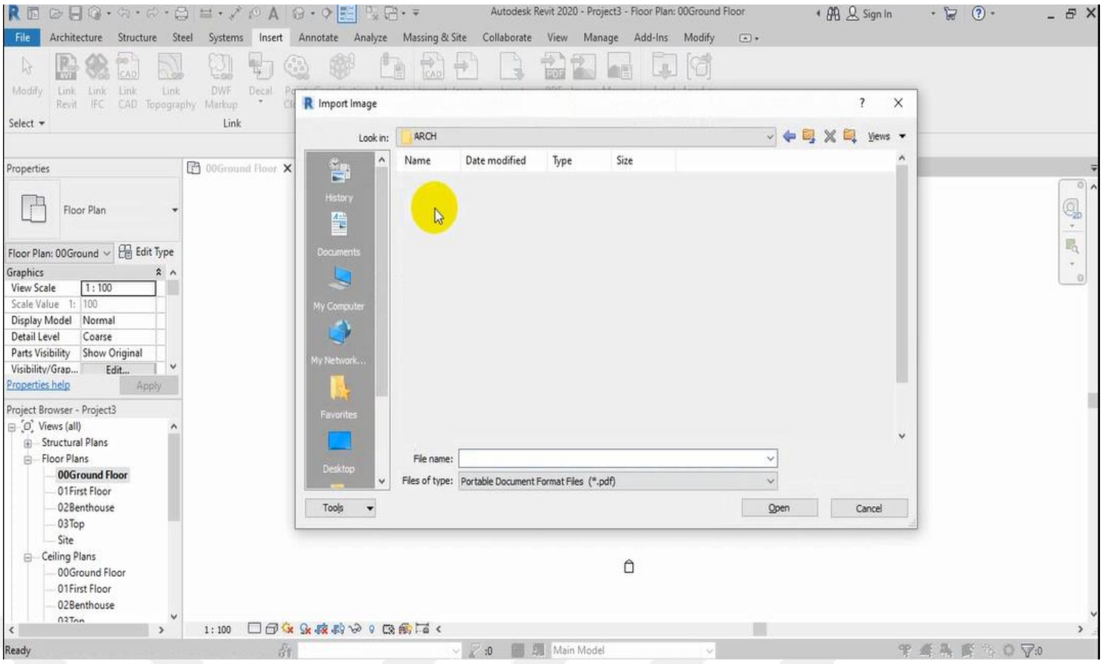


Figure 4.5: Inserting PDF Plans.

After inserting the pdf file into the program, as shown in the figure below:

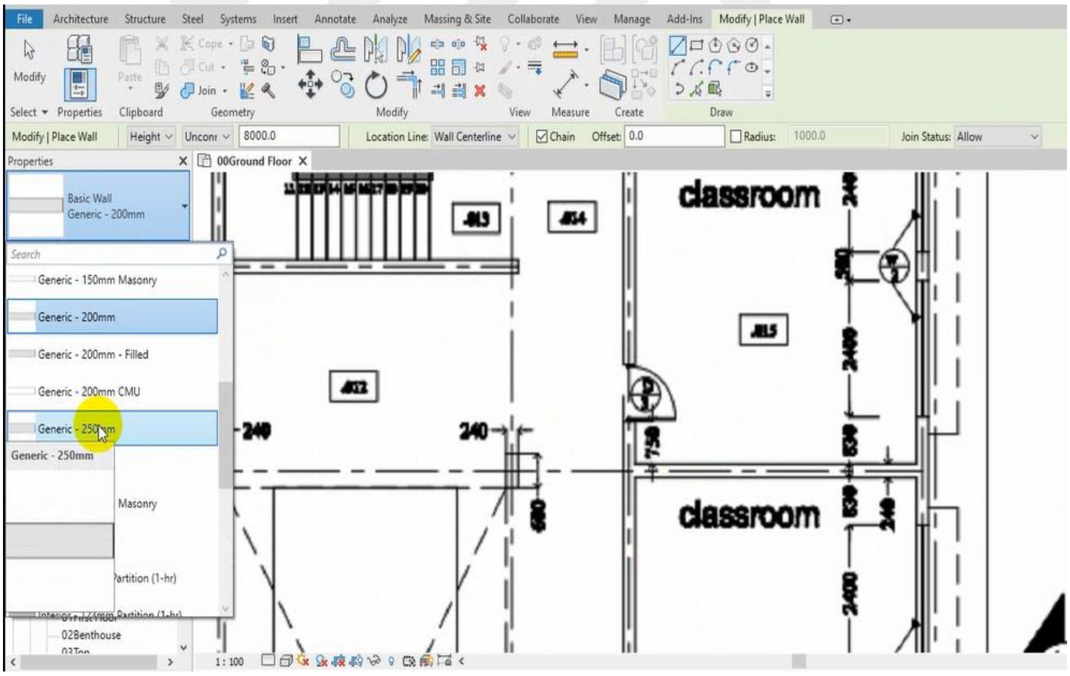


Figure 4.6: Inserting PDF for Arcetictural plans

The plans launching begins with drawing the walls determining their type and thickness by choosing Edit Type as shown in the figure below:

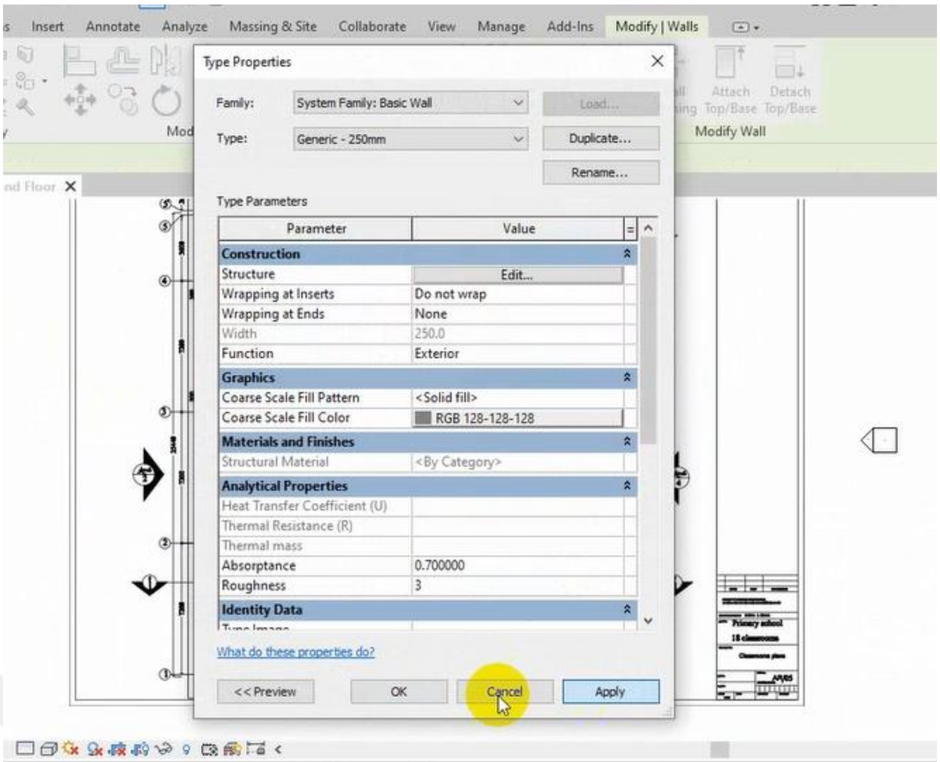


Figure 4.7: Creating Walls of the building

After drawing all the walls of the building, the model is given and it can be moved as shown in the figure below:

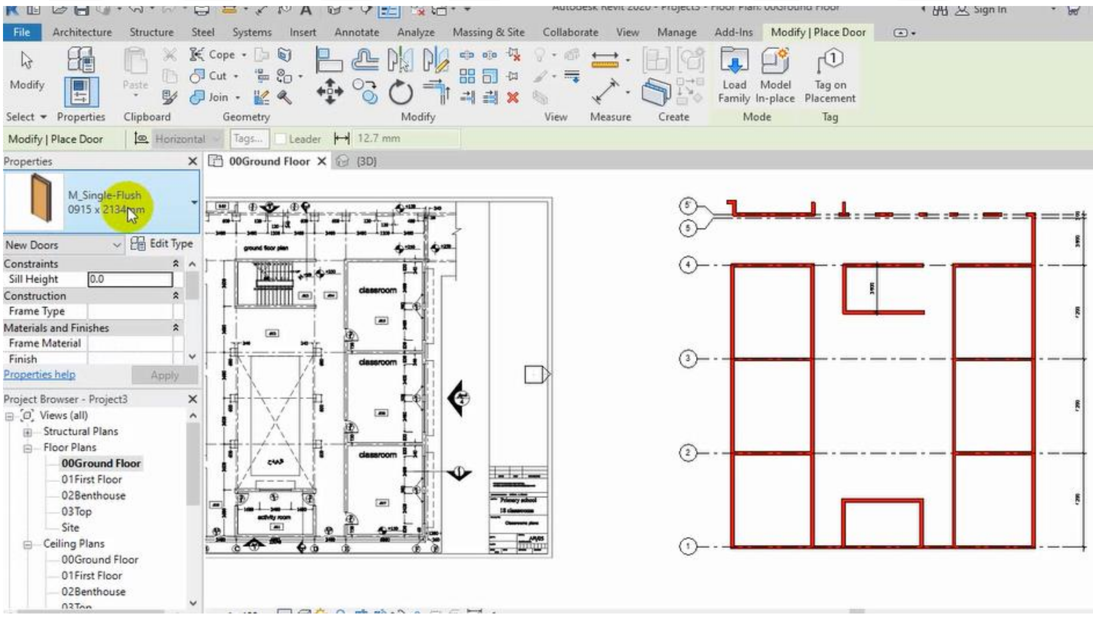


Figure 4.8: The Building After Creating Walls

Then, the floor of the building is drown by choosing *Floor* as shown in the figure below:

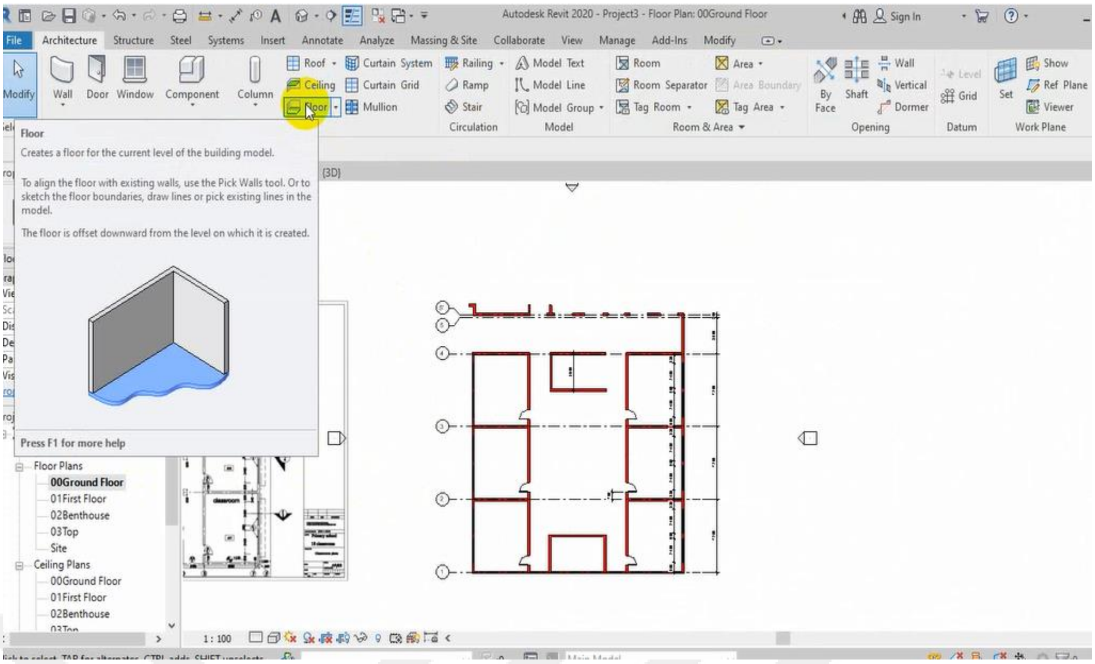


Figure 4.9: Arcetictural Drawing For Level 0 (Ground Floor)

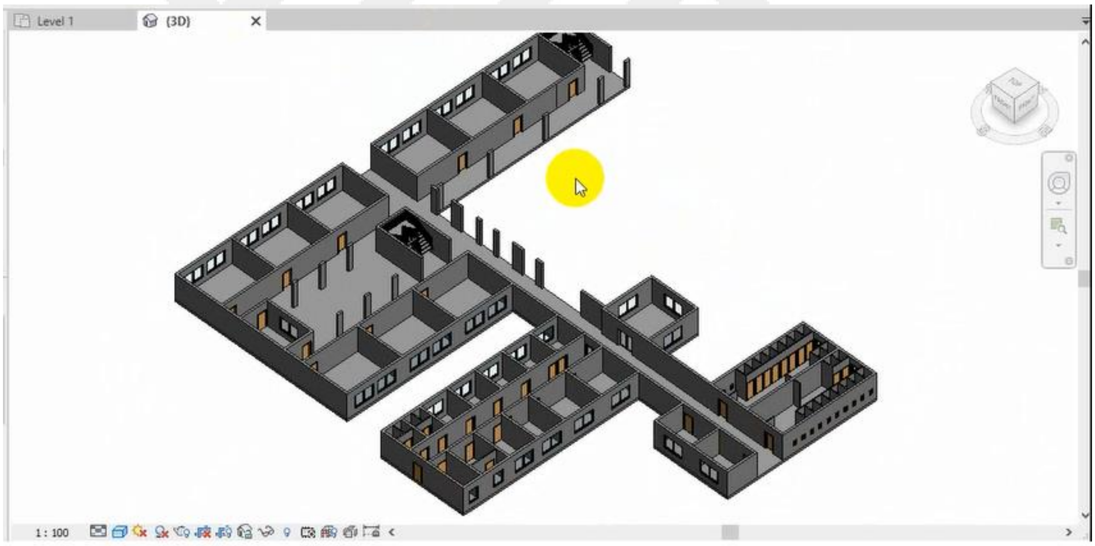


Figure 4.10: 3D View For Level 0 (Ground Floor)

The second floor is done by pressing Copy then Paste to the selected level as shown in the figure below:

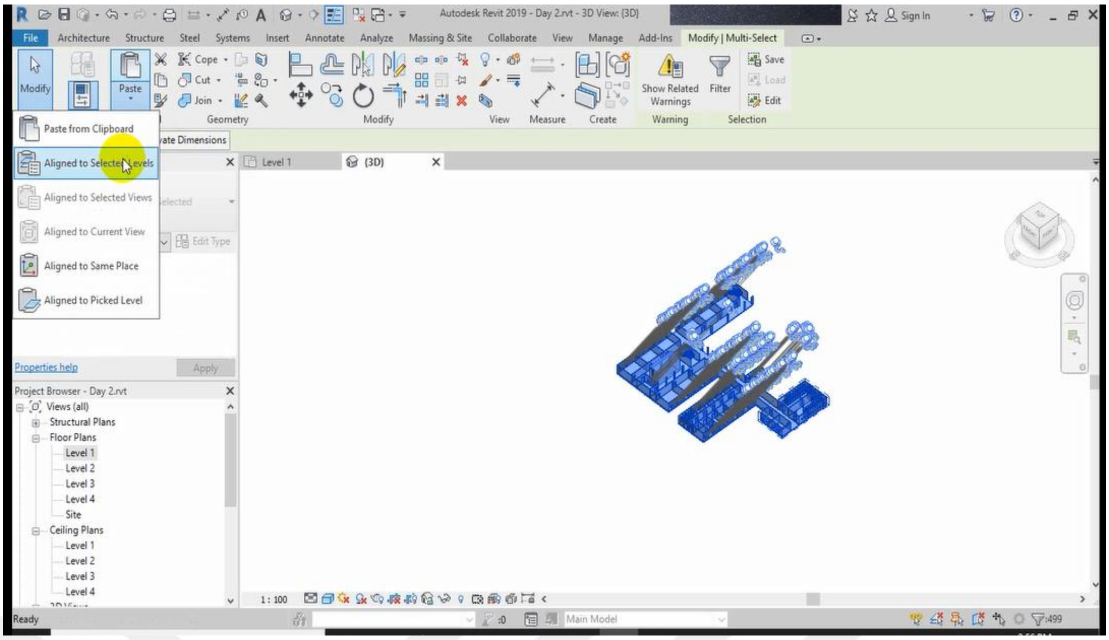


Figure 4.11: Copy For Level 0 (Ground Floor)

Then select level 2 as shown in the figure below:

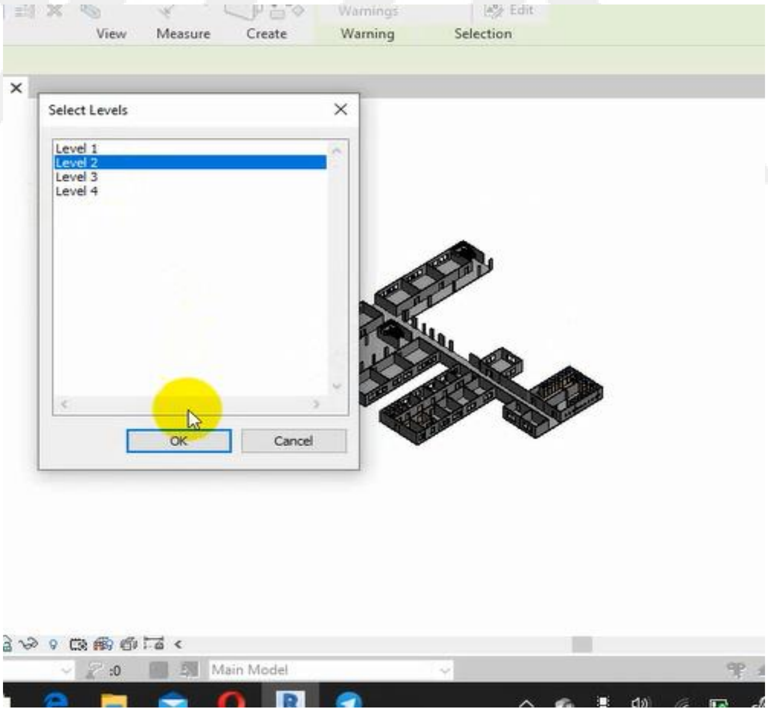


Figure 4.12: copy For Level 0 to draw (first Floor)

Finally, drawing the Architectural model is finished as in the figure below:

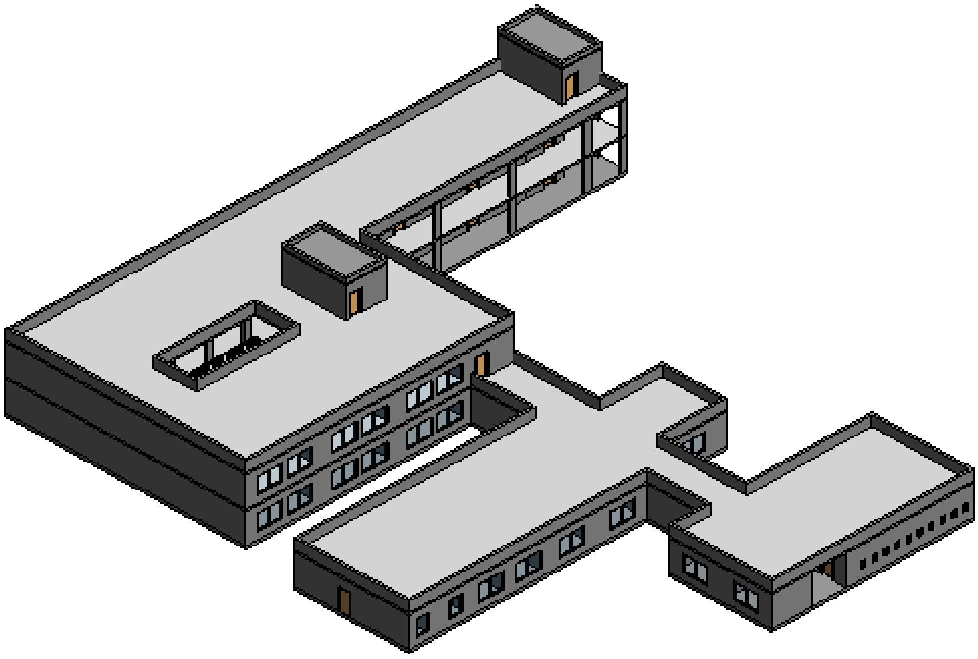
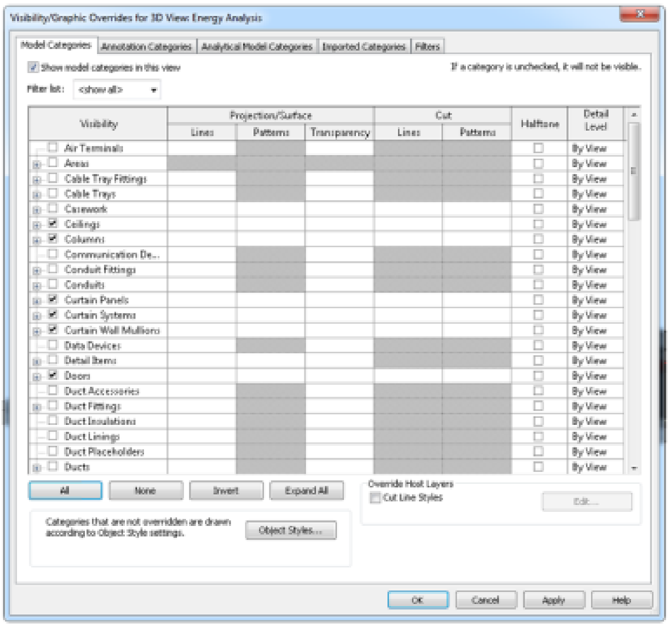


Figure 4.13: 3D Model of the School Building

4.4.2 Building elements

Most Revit models can be used to create a decent EAM. The elements listed in the image below (Figure 4.14), when set to Room Bounding, are used in the EAM creation.



- √ Ceilings
- √ Columns
- √ Curtain Panels
- √ Curtain Systems
- √ Curtain Wall Mullions
- √ Doors
- √ Floors
- √ Roofs
  - √ Common edges
  - X Fascias
  - X Gutters
  - √ Hidden Lines
  - √ Interior Edges
  - √ Roof soffits
- √ Shaft Openings
- √ Site
  - X Hidden Lines
  - X Landscape
  - √ Pads
  - X Project Base Point
  - X Property Lines
  - X Stripe
  - X Survey Point
  - X Utilities
- √ Structural Columns
- √ Walls
  - √ Common Edges
  - √ Hidden Lines
  - X Walls Sweeps – Cornice
- √ Windows

Figure 4.14: Determine Building Elements

4.4.3 Materials properties

In this research, the American standards are used (the millimetre units at the beginning of drawing of the project). As for the family units, US metric units are utilized.and the characteristics of the building s thermal in the BIM model is shown in the table below:

Table 4.1: Characteristics of building's thermal envelope in the BIM model.

Building's thermal envelope	Thickness (mm)	Thermal transmittance (w/m2 k)
Facade wall	300	1.88
roof	200	0.322
Floor	200	0.32
glass	5	6.6
Outer doors	50	2.04

4.4.4 Energy settings

When selecting Analyse and then Power Settings, the following dialog box will appear

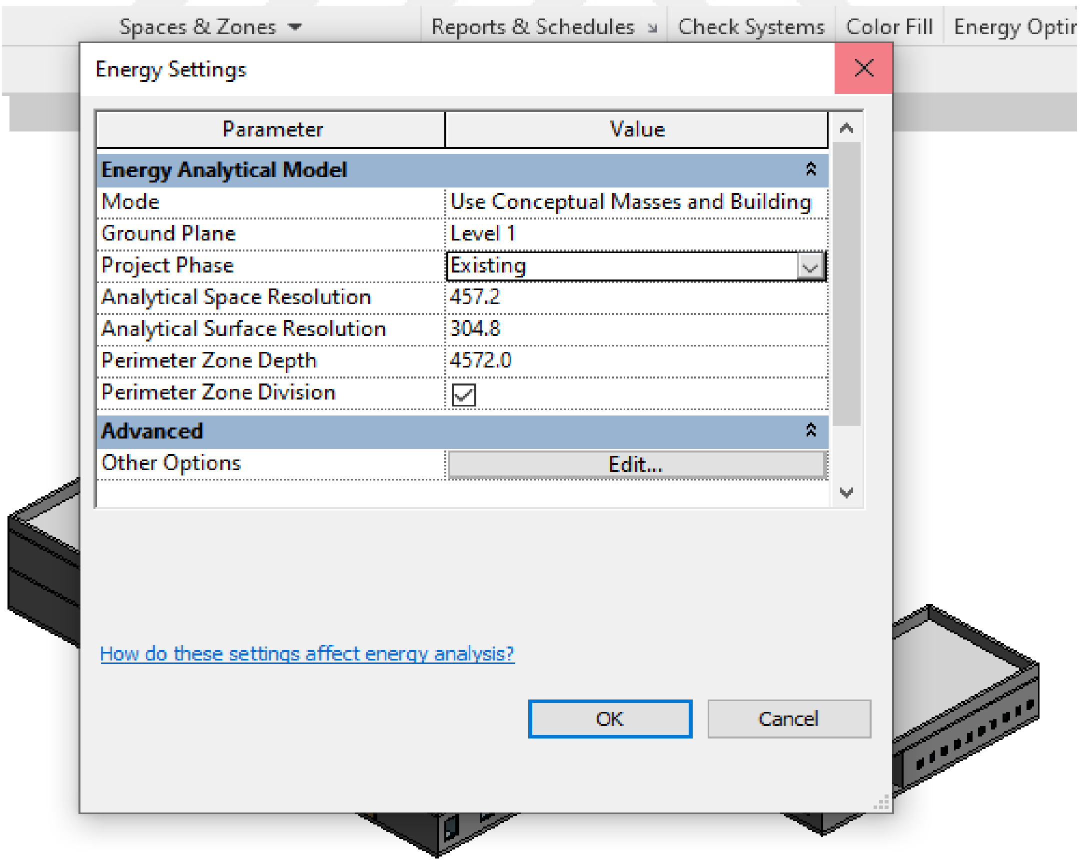


Figure 4.15: Determine Energy Settings

Through the dialog box, the type of building is chosen whether it is existing or new. Then, the number of hours of operation of the building is determined by pressing the Edit option.

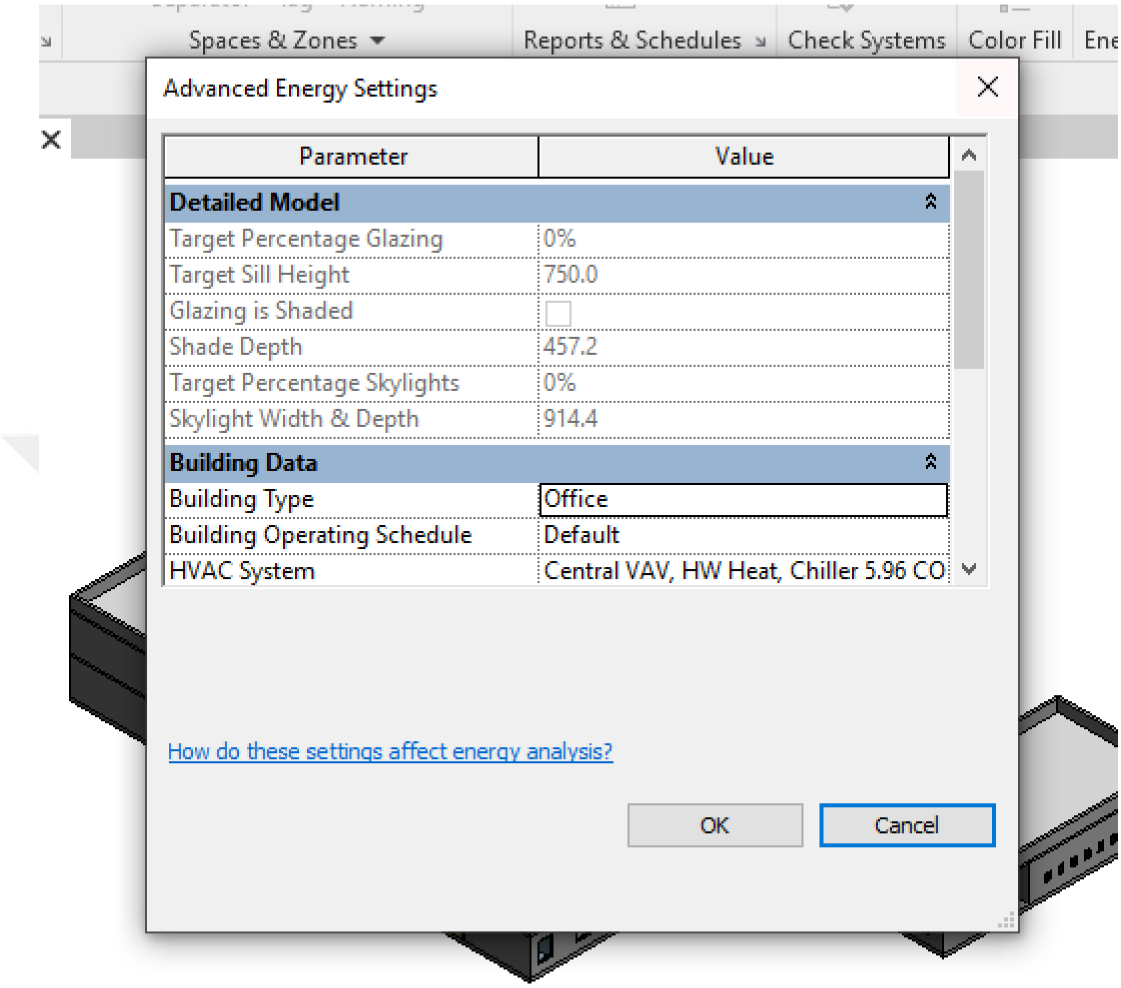


Figure 4.16: Determine Advance Energy Settings

Later, the structure is located. The Location option gives localized weather and utility data which is essential for constructing a valid energy simulation. To precisely identify a location, there are two steps: project location and weather situation. The project location identifies the project physical location on the planet. A city, a specific postal address, or Lat/Long data can all be used. If the project site lacks an address, type in the city name and then drag the Project Place Pin (red) to the desired location on the map. In this map view, one can zoom and pan, as well as make the dialog larger. In this research, the selected the specific location is Baghdad/ Iraq.

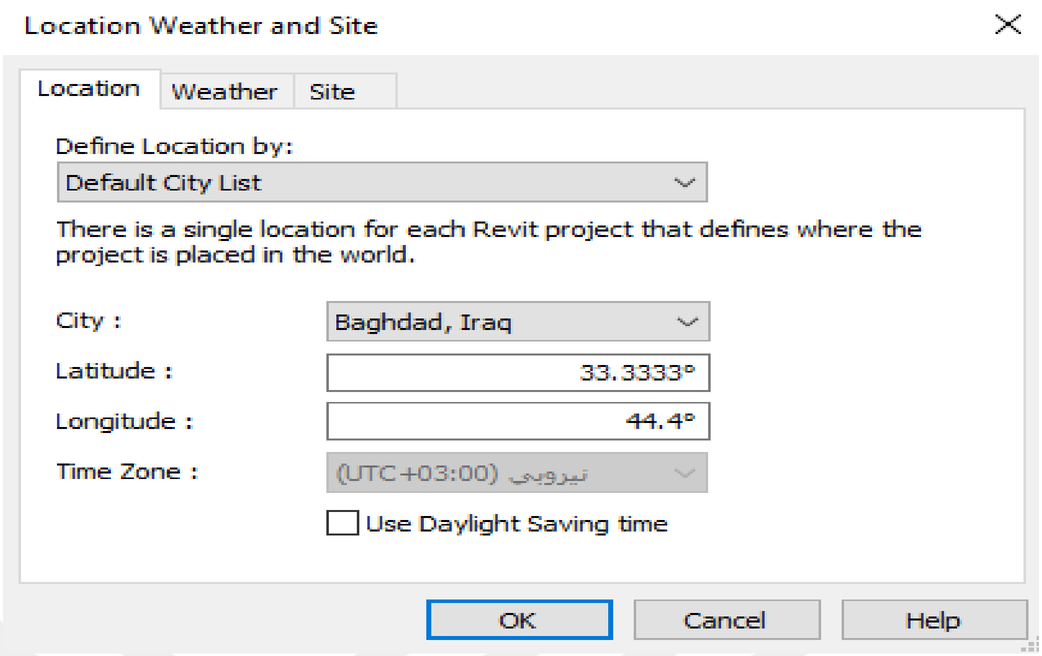


Figure 4.17: Determine the Location of the building

4.4.5 Creat energy model

By using this tool, it generates an Analytical Model.

The Revit form is used to produce three linked views:

- 3D energy model
- Analytic distances (table)
- Analytical surfaces (table)

It allows the designer, if built, to visually check the accuracy of the model before running the simulation. As mentioned, Room Bounding Power Analytic Model is generated.

Within a Revit form, there are various elements. The end product is a simplified model made up of skins similar to those found in SketchUp. The designer can ensure that there are no abnormalities before the simulation begins by selecting surfaces and modifying the vision of the 3D power model display.

Models must be designed correctly when more analysis tools like this become accessible. Ceilings, for example, should not be utilized as floors, and floors should not be used as counters. If thin flooring is utilized as finishing over a structural floor, Room Bounding should be unchecked.

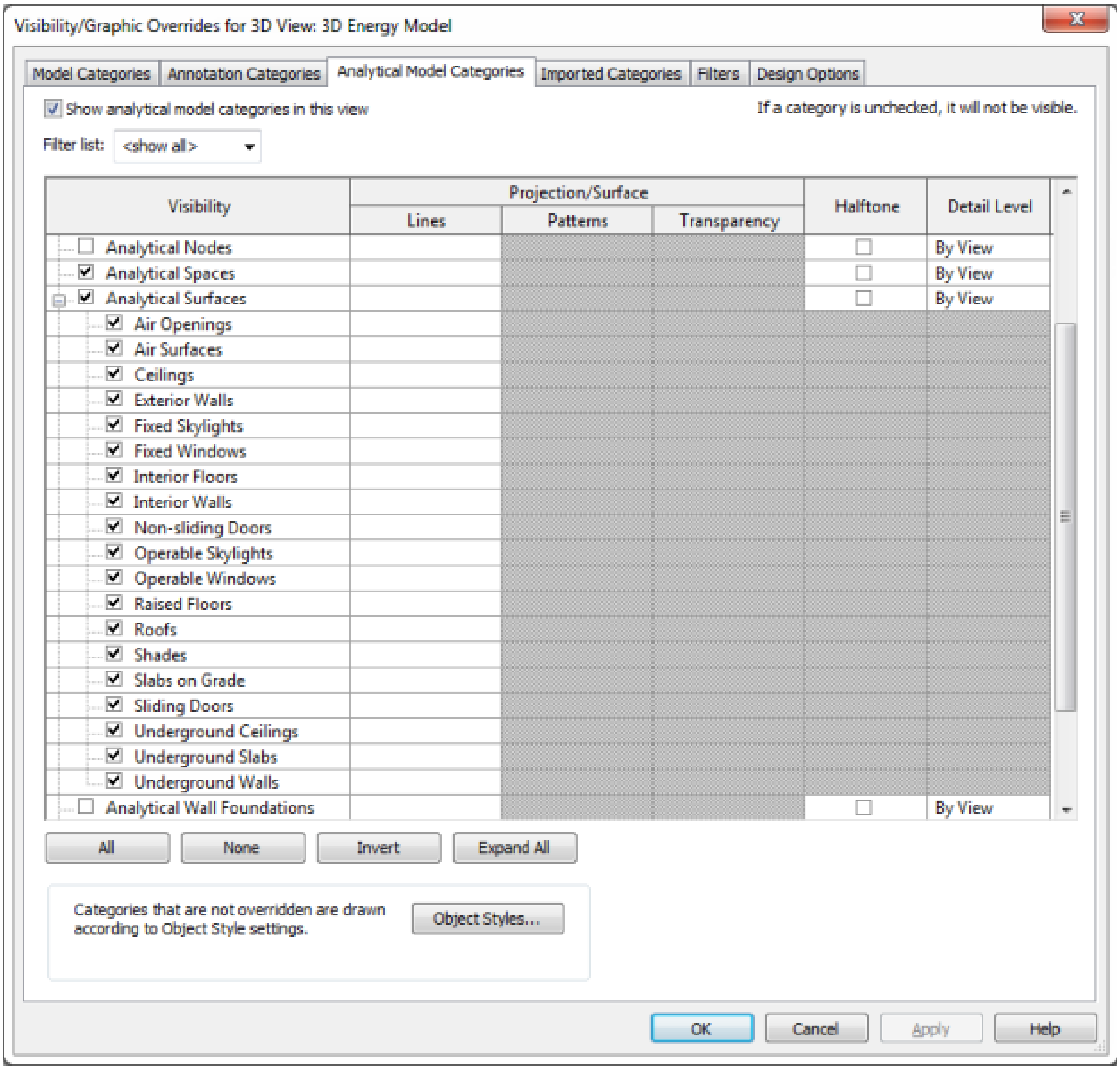


Figure 4.18: Analytical Spaces and Surfaces in Visibility/Graphic Overrides Dialog for 3D Energy Model View

It is crucial to realize that the analytical surfaces do not automatically update as the model changes. The EAM must be removed and regenerated whenever the Revit model changes. Some of the sub-categories of Analytical Surfaces may be perplexing. Even if they are not operable, Revit Windows are translated to an analytical surface termed Operable Windows, while Curtainwall walls are all referred to as Fixed Windows.

4.4.6 Visually review energy model

It is important to visually validate the energy model before simulating it to ensure valid results.

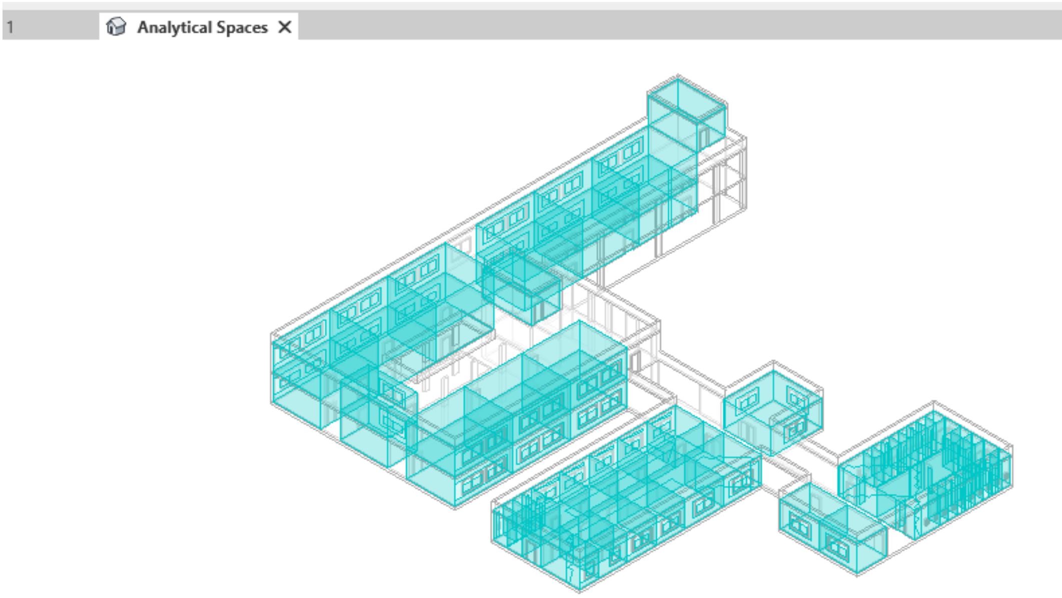


Figure 4.19: 3D Energy Model View, with Analytical Spaces, and Surfaces

4.4.7optimization options

The outcomes of this study are influenced by the energy choices in Revit 2020 as well as the scenario chosen in Autodesk Insight 360 cloud. The 3D model in the Insight 360 cloud is shown in figure 4.20. The following conclusions were drawn:

Figure 4.20: 3D Model in Insight360

The insight program provides many scenarios to improve the performance of the building, including:

4.4.7.1 Building orientation

Building trends are taken into consideration because of their function in lowering energy consumption and increasing indoor air quality. However, Insight360 analysis helps designers and architects determine the best orientation for a building to impose lower energy usage. When performing the orientation analysis for any building, we can conclude that by rotating the building between 0° to 360°, the amount of EUI and energy costs differ slightly, and this is insightful in making design decisions, but in our case study, this is not available because the building is standing.

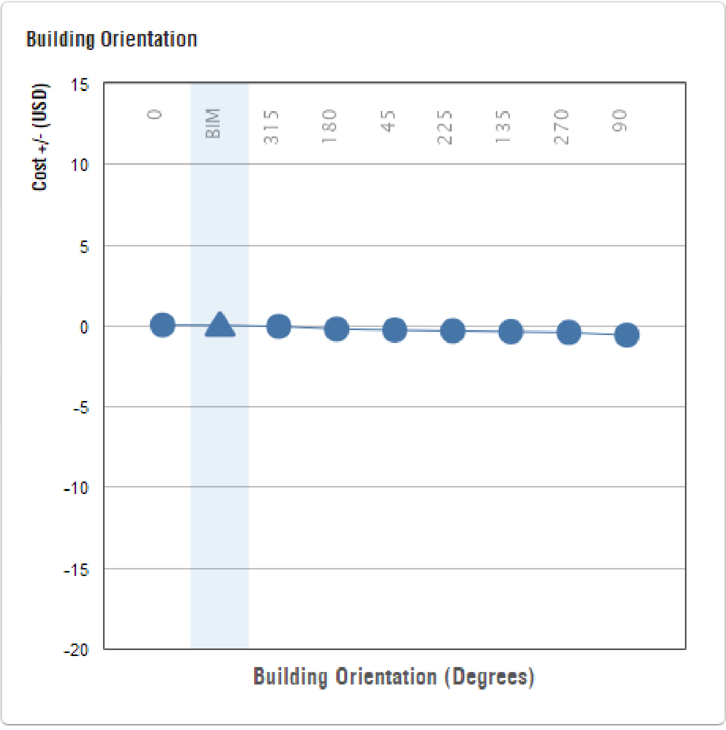


Figure 4.21: Building Orientation

4.4.7.2. Window-to-wall ratio (WWR)

Because a substantial amount of solar heat gain is through external windows to obtain a high solar radiation intensity and average yearly temperature in tropical climates, the window-to-wall ratio (WWR) plays an important role in the forecast of energy consumption.

The window-to-wall ratio is considered since it has a significant impact on energy usage. Figure 4.22 depicts the usage of a window-to-wall ratio (65-95%) in the southern walls to reduce energy intensity, as well as a window-to-wall utilization ratio (0-95%) in the northern walls to minimize energy intensity. Figure 4.23 shows that the northern walls window-to-wall ratio has a bigger impact on energy intensity than the southern walls window-to-wall ratio. As a result, the northern walls window-to-wall ratio should be lowered in the building design. Figure 4.24 demonstrates that in western walls, the window-to-wall ratio (0-95%) reduced energy intensity, whereas, in eastern walls, the window-to-wall ratio (0-95%) reduced energy intensity. Figure 4.25 illustrates that eastern walls are more susceptible to changes in window-to-wall ratio than western walls. To use sunlight for artificial lighting, a larger window-to-wall ratio for western walls can be employed, while maintaining the window-to-wall ratio for eastern walls lower.

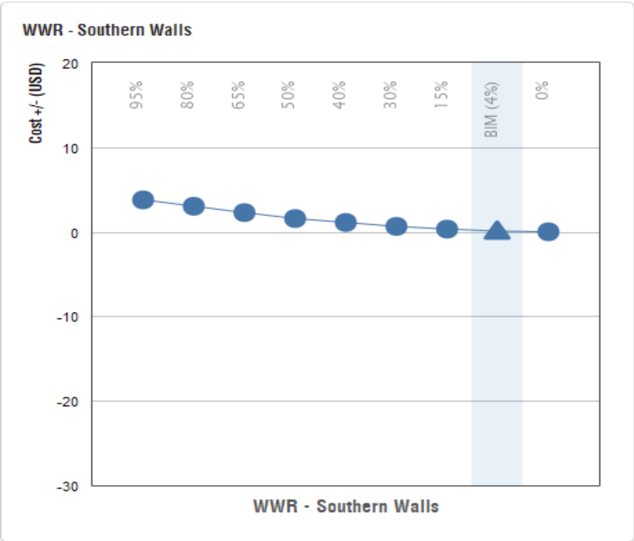


Figure 4.22: WWR in Southern

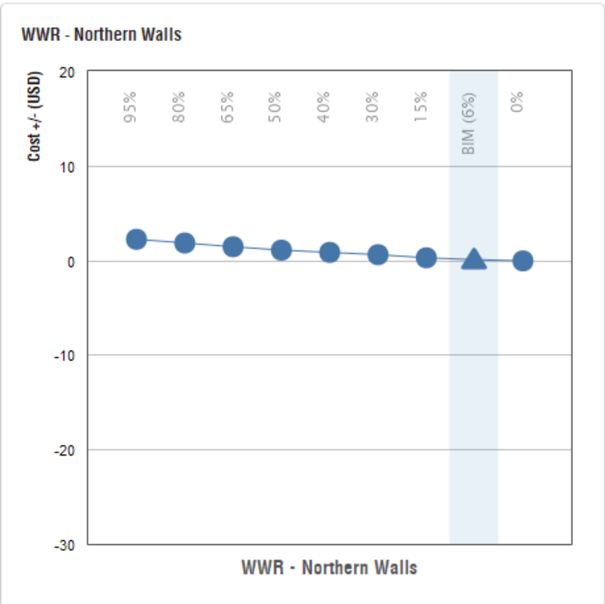


Figure 4.23: WWR in Northern Walls

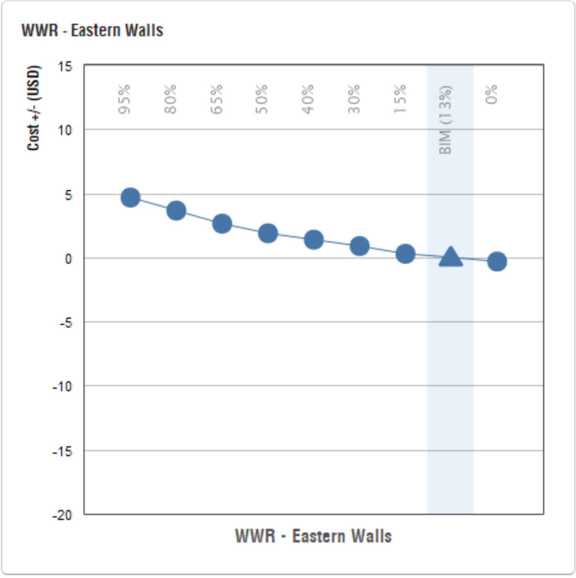


Figure 4.24: WWR in Eastern Walls

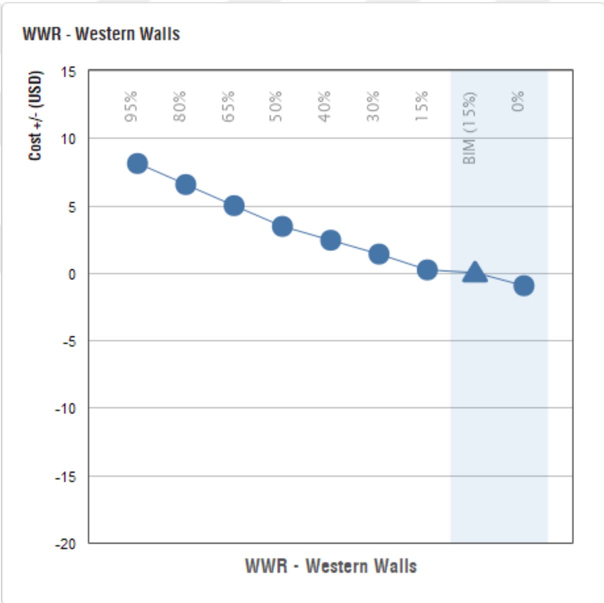


Figure 4.25: WWR in Western Walls

4.4.7.3 Windows glass type

In building design, the type of glass is taken into consideration as it plays an important role in reducing energy considerations. The figures show how triple Low-E glazing is used in the windows of the southern walls for low energy. The figures show that all types of glass are similar in terms of their impact on energy intensity.

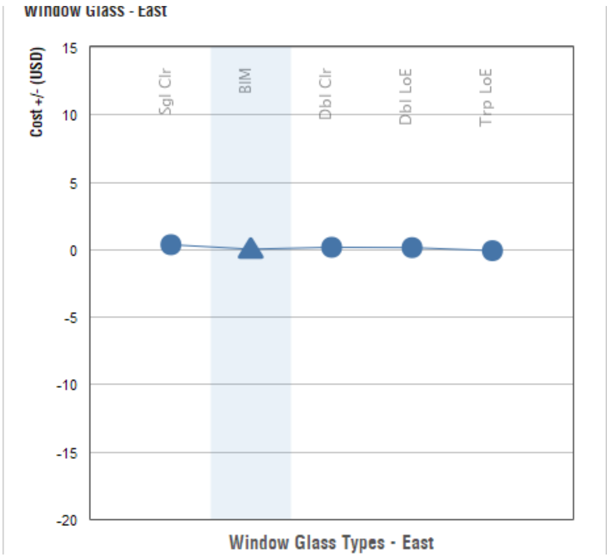


Figure 4.26: Windows Glass Type (East)

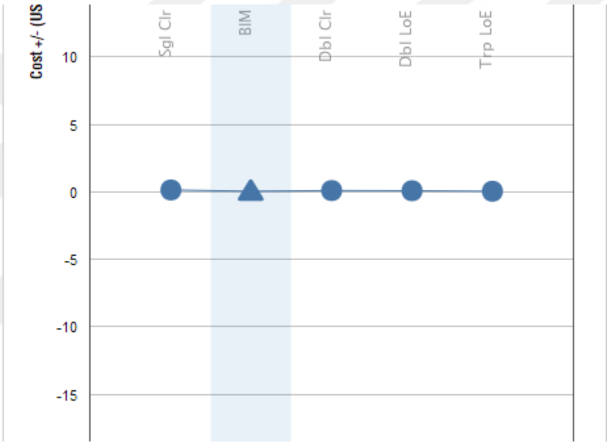


Figure 4.27: Windows Glass Type (North)

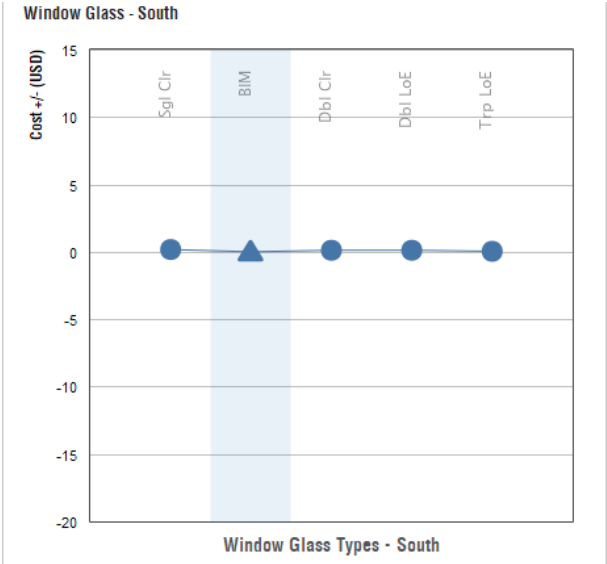


Figure 4.28: Windows Glass Type (South)

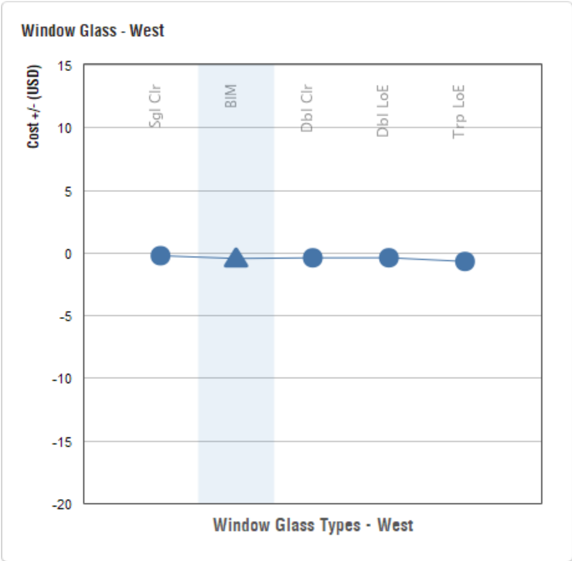


Figure 4.29: Windows Glass Type (West)

4.4.7.4 Windows shades

In building design, window shades are taken into account as they play an important role in reducing energy considerations. Figure 4.30 shows the use of shadows in window walls to reduce energy.

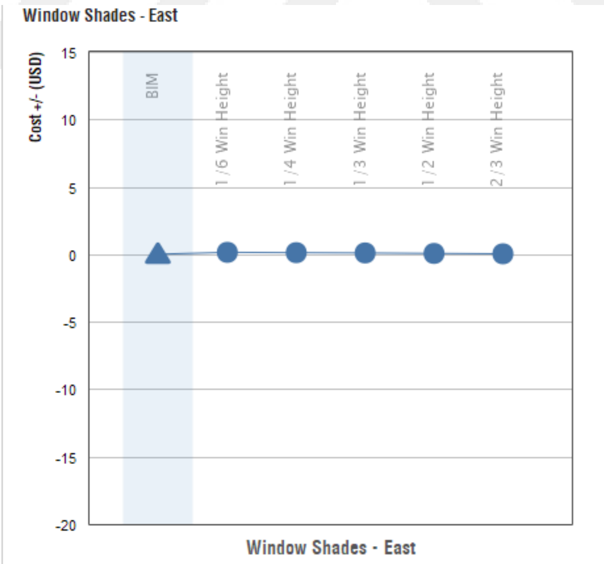


Figure 4.30: Windows Shades (East)

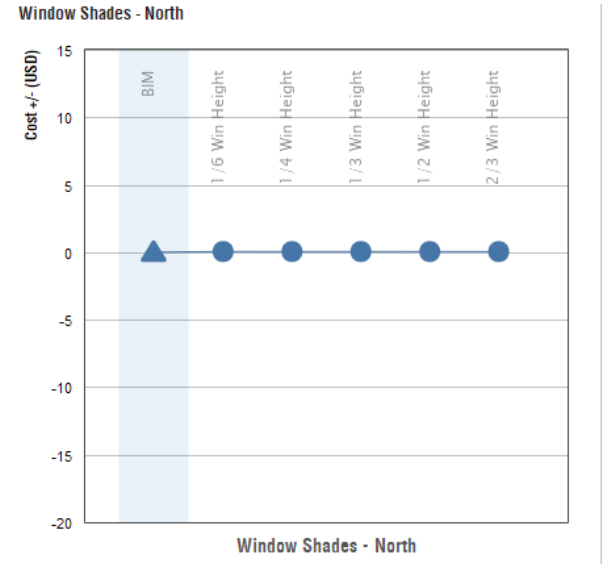


Figure 4.31: Windows Shades (North)

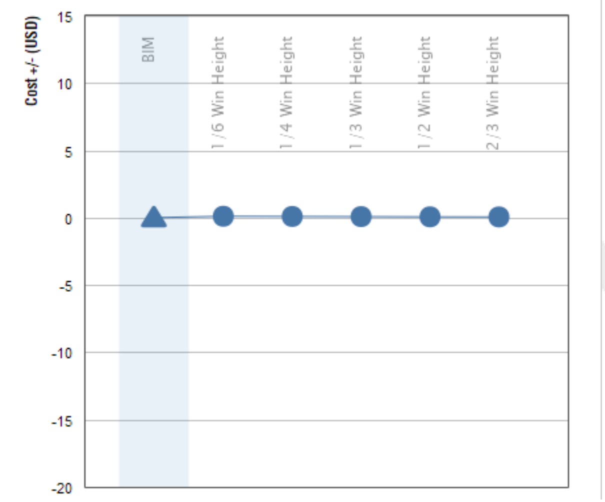


Figure 4.32: Windows Shades (South)

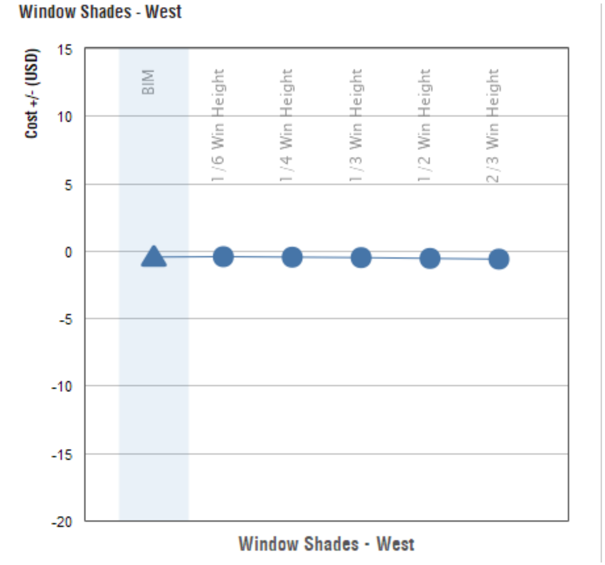


Figure 4.33: Windows Shades (West)

4.4.7.5 Wall construction

When developing a building, the type of wall is considered because it has a significant impact on energy usage. Figure 4.34 depicts various types of sustainable building walls and their impact on energy intensity. The analysis demonstrates that utilizing an IF impact on energy usage C (Insulated Concrete Form) wall saves energy. It also emphasizes the need for wall insulation because it enhances the wall thermal resistance, which has a substantial.

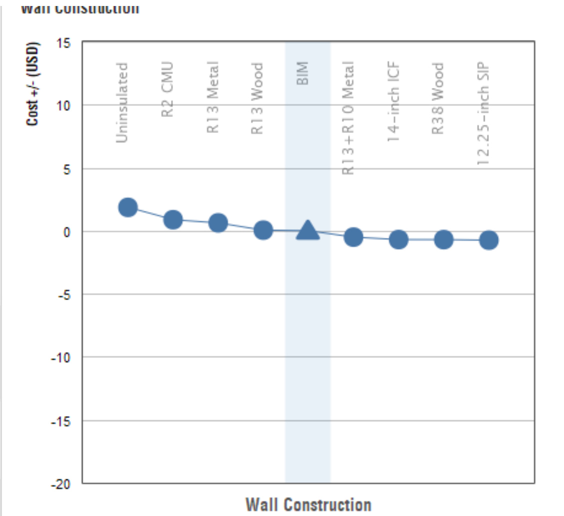


Figure 4.34: Wall Construction

4.4.7.6 Roof construction

The impact of various forms of insulation on energy intensity is shown in this analysis. The rate of thermal insulation in the roof has an impact on the intensity of energy use, as shown in Figure 4.35

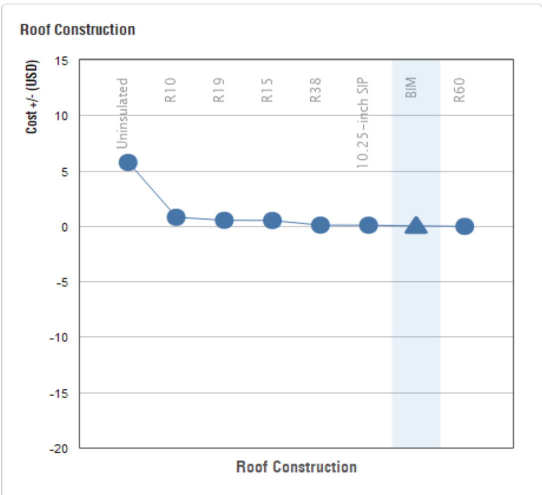


Figure 4.35: Roof Construction

4.4.7.7 HVAC System

The HVAC system is a major component of energy use, and the HVAC system affects indoor air quality and the air temperature in a building. Figure 4.36 shows the effect of changing the heating and cooling system on reducing energy use. The kind of HVAC system we used in our building is a split unit.

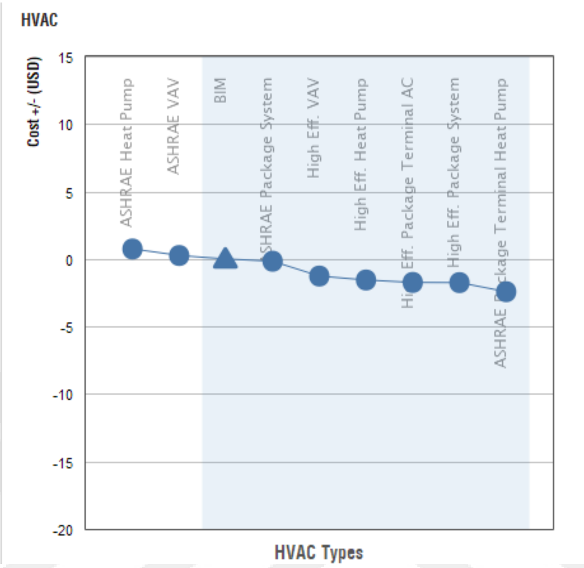


Figure 4.36: HVAC Types

4.4.7.8 Infiltration

In the building design, sequential steps are taken into consideration as it plays an important role regarding minimizing energy considerations. The figure below shows the use of stealth to reduce energy**:**

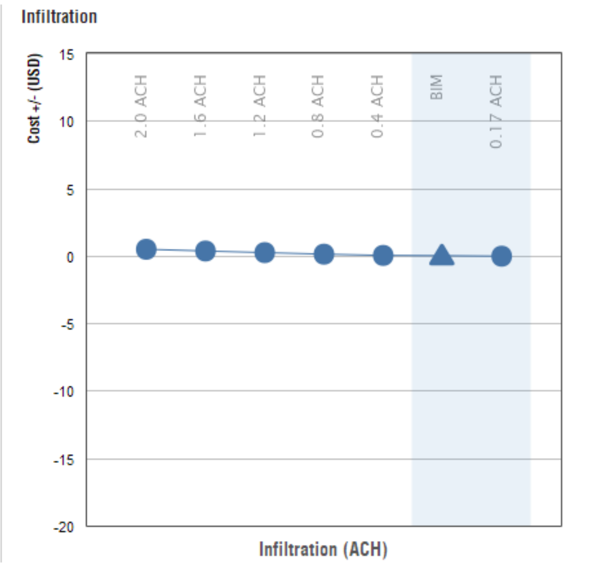


Figure 4.37: Infiltration

4.4.7.9 Lighting efficiency

When reducing energy in a building, lighting efficiency is considered as it plays an important role in reducing energy considerations

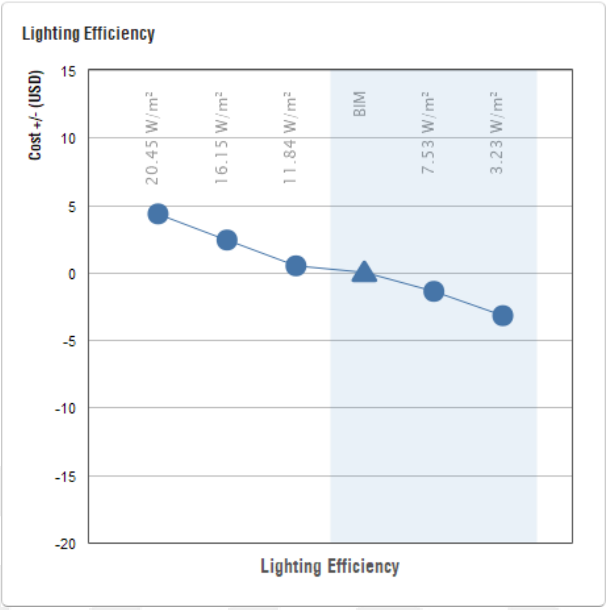


Figure 4.38: Lighting Efficiency

4.4.7.10 Daylighting & occupancy controls

When optimizing a building energy performance, daylighting and occupancy controls are taken into account as they have an important role in reducing energy considerations

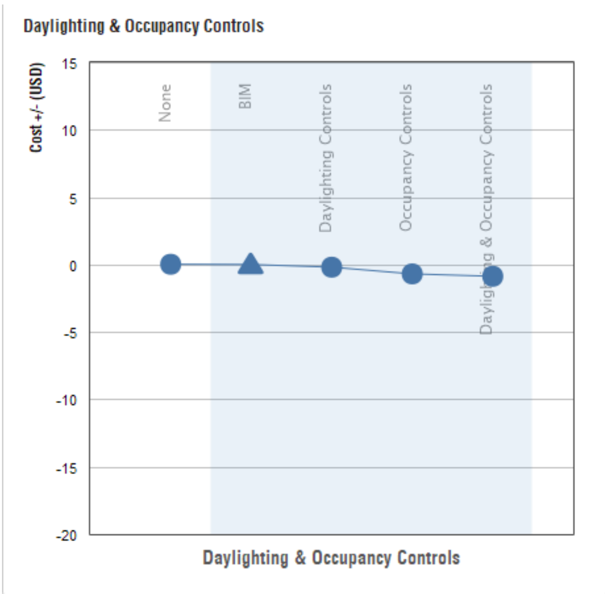


Figure 4.39: Daylighting & Occupancy Controls

4.4.7.11 Plug load efficiency

Component loading efficiency is taken into account while optimizing a building energy performance since it plays an essential role in lowering energy costs. Figure 4.40 shows how stealth can be used to save energy

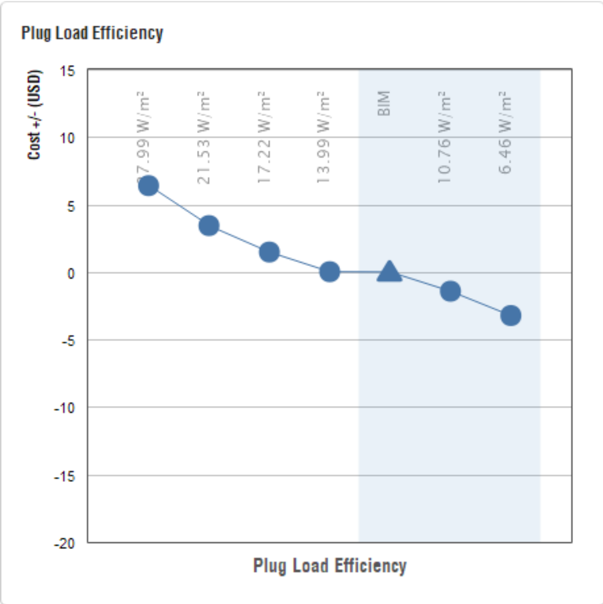


Figure 4.40: Plug Load Efficiency

4.4.7.12 Operating schedule

When optimizing the energy performance of a building, the operating schedule is taken into account as it plays an important role in reducing energy considerations. Figure 4.41 shows the use of stealth to reduce energy:

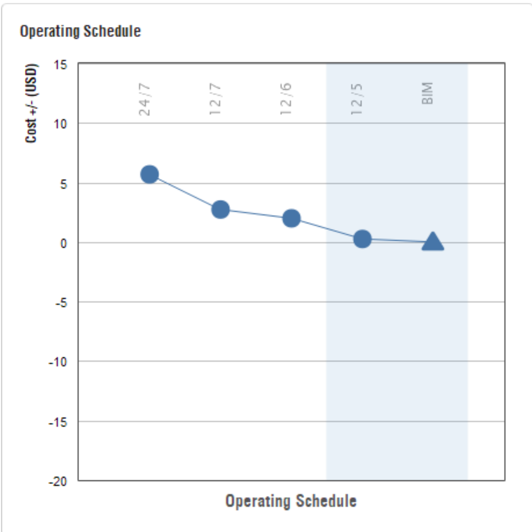


Figure 4.41: Operating Schedule

4.4.7.13 Photovoltaic PV Panels

The panels are one of the most important sources of renewable energy in the world, and their use allows to benefit from solar energy. The Insight 360 study helps to understand the influence of photovoltaic panels on the intensity of energy use. Photovoltaic panels have a substantial impact on energy intensity since energy intensity is reduced. In autodesk insight 360, there is no sufficient details for the number of panels used, cost of kwh of PV ststem and it's calculated by default, so it is found that detailed – equation calculations are more suitable to insure the accuracy of the results.

PV panel calculation

A-Hand Calculation

Solar radiation potential of a region can be determined from meteorological data and solar radiation data of national or international energy organizations or solar radiation maps. or, annual solar data are measured with a special pyranometer device and hourly solar radiation power averages are recorded. the solar radiation data was obtained from the PV*SOL online tool. the solar radiation data was obtained for our location from the PV*SOL online program. This tool has the feature of input basic data like location of country and city or load profile and annual energy consumption The annual radiation value ($I_{annual,global}$) for Baghdad from the PV-SOl program was used 1823 kWh/m^2 as shown in Figure 4.42.

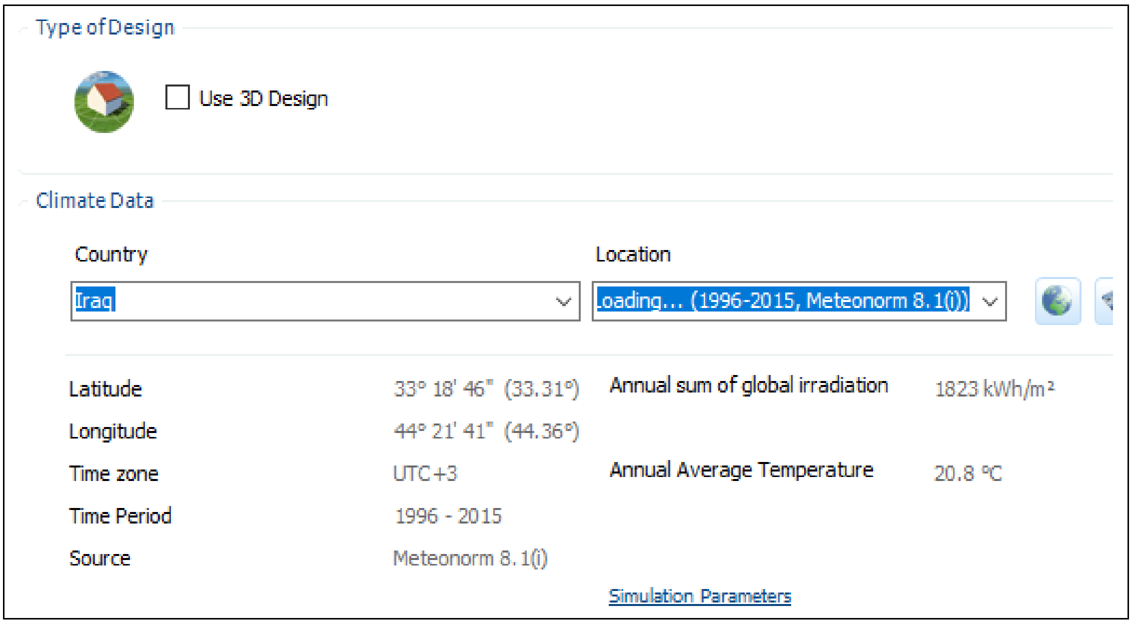


Figure 4.42: Annual Sun of Global Irradiation

<u>Kwh when Amps are known on a 3 phase board</u>

<u>MDB</u>

Connected Load = 100A

Demand Load = 100 x 0.6 (D.F) = 60A

Power =1.732 x V x I x Power Factor, V = Voltage I = Current

=1.732 x 380 x 60 x 0.8 = 31.6 = Approximate 30KW

Energy (Kwh) = P(KW) x t (hours)

30 KW x8(hours) = 240 KWh, (from 8 AM to 4 PM) the reading are higher during the day.

Energy use monthly =240*30 kwh month = 7200 kwh/month

Total Annual consumption = 7200 kwh/month x 12 months = 86400 Kwh/year

When the average daily radiation amount (I daily, avarage) is calculated from the equation (4.1), daily radiation amount of 5 [kWh/m2] was obtained.

$$I_{daily,\ avarage} = I_{annual,global} / 360 \qquad \textbf{(4.1)}$$

The annual efficiency of the panel (η PV) to be used was determined as 14 percent.

Ŋ PV =0,14

The optimum tilt angle to be used for the photovoltaic panels used was determined as 30° for Baghdad (Mark Z. Jacobson , Vijaysinh Jadhav,2018)

The energy that the photovoltaic panel can generate (E PV day) per unit square meter in one day calculated from equation (4.2)

$$E_{PV\ day} = I_{daily,\ average} * \eta_{PV} \qquad \textbf{(4.2)}$$

$$= 0.7$$

After calculating the energy that the photovoltaic panel can produce, we will use equation (4.3) to determine the average monthly energy (E average monthly) we will use.

$$E_{average\ monthly} = 0.7*30=21 \qquad \textbf{(4.3)}$$

Number of panels required

Energy generated by a panel in each month=Daily_glabol_irradiation*panel surface area*eta_PV*number of days in a monthEnergy generated by a panel in each month=E_generated_panel_month

Panel Surface Area=A_panel

A_panel= 1.62 [m^2]

E_generated_panel_month=Daily_global_irradiation*A_panel*eta_PV*30 [kW/panel]

= 0.7*1.62*30

= 34 Kwh/month

Panel_number_needed=Energy_use_montly/E_generated_panel_month

34/7200 = 212 we can take 220 panel (total Area = 356.4 m2)

We take Mono crystalline type (BP solar 3230N)

The nominal output of the panel is 250 WP

Nominal output of the PV system = 220 * 250 = 55,000W = 55 KWP

Annual generated energy= 1823 Kwh/m2/year * 356.4 m2 * 0.14 = 93257 kwh/year

Which is greater than the actual consumption of the building (86400 Kwh/year)
Cost calculations :

In this calculations, the exchange price will be taken as 1$ = 1440 ID (central bank of Iraq).

A unit of Electricity is about 100 ID x 240KWh = 24000 ID per day (for average 8 hours) x 30= 720000 ID per month. = 500$

Total panel= 220 panel , 55 KWP

Price for I kw = 900$

PV system = 55 * 900 $

= 49500 $ Total investment price for pv system

500 $ / month is spent without using pv

500 * 12 month = 6000 $/year

Pay back limit = 49500$/6,000$ =8.3 year

B-PV Solar calculation Report (PV *SOL premium 2020)

1-PV system

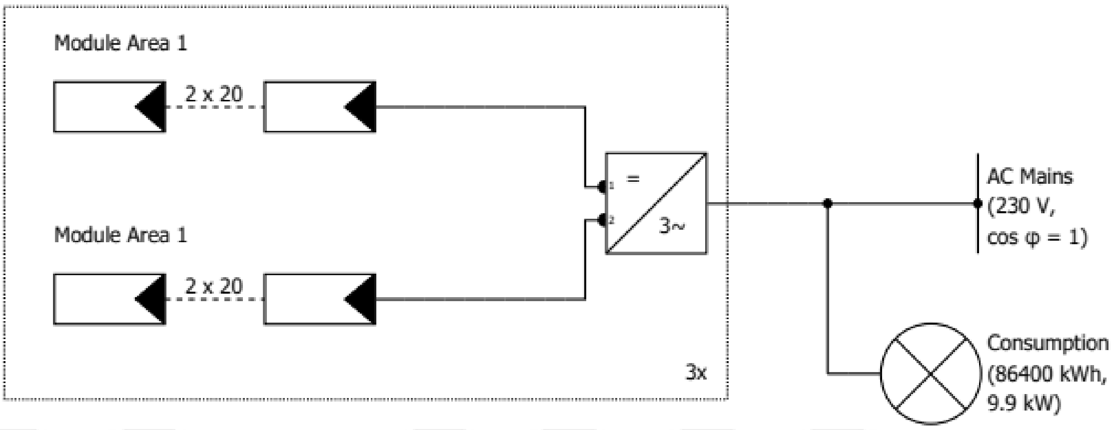


Fig 4.46 Grid_ connected PV system with Electrical Appliances

Table 4.2: PV system details

PV Generator output	55.2 KWp
PV Generator surface	400.1 m2
Number of PV modules	240
Number of invertores	3

Table 4.3: Parts list for PV system.

Position number	Type	Manufacturer	Name	Quantity	Unit
1	PV Module	BP solar	BP 3230N/3230T	240	Piece
2	Inverter	Huawei technologies	Sun2000 15KTL-M2	3	Piece

Table 4.4: Production Forecast

PV System	
PV Generator output	55.2KWp
Spec .Annual yield	1687.02 Kwh/Kwp
Performancr ratio(PR)	84.91 %
Pv Generator energy (AC Grid)	93201 Kwh/year
CO2 Emissions avoided	43768 Kg/year

Table 4.5: Financial Analysis

Cost Analysis	
Total invesment costs	49680 $
İnternal rate of returen (IRR)	10.54 %
Amortization period	8.5 years
Elecitricy prodection cost	0.0254 $/kwh
Energy balance/feed_in concept	Net metering

Set up on the system

Total consumption = 86,400 kwh, load peak=9.9 kw

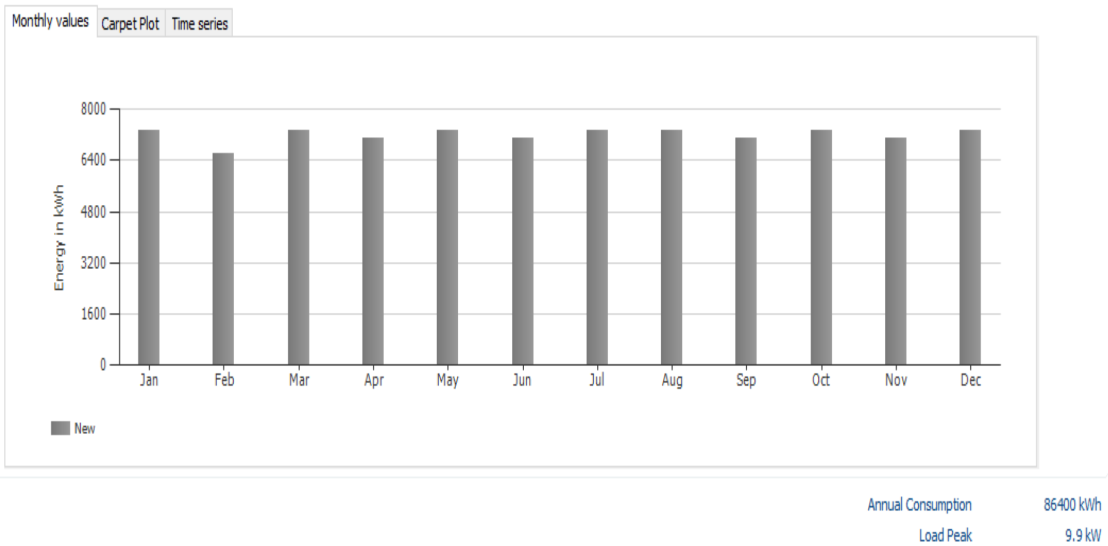


Figure 4.43: Total consumption

2-Module Area

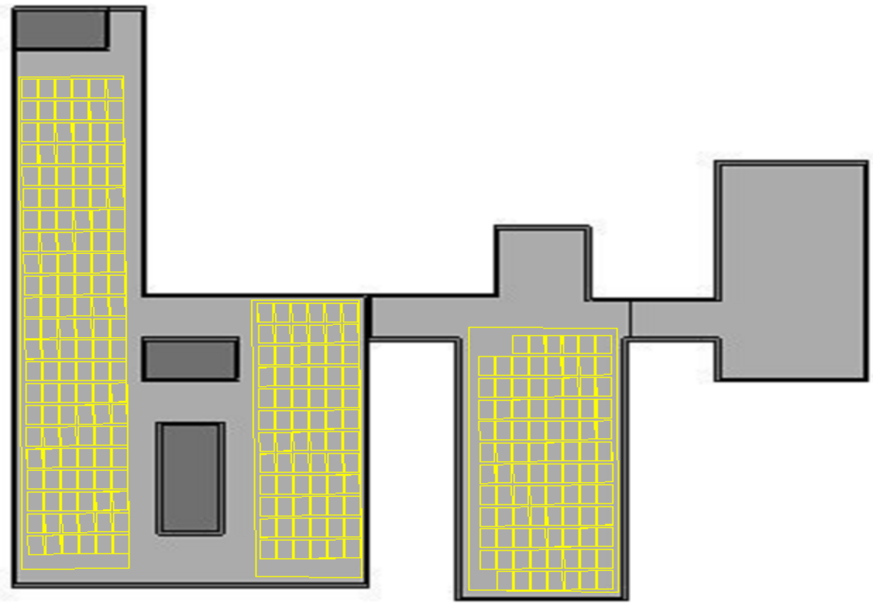


Figure 4.44: Module Area

Table 4.6: Module Area details

PV Module 200 wp _si monocrystlline	
Manufacter	Bp Solar
İnclination	30
Orientation	180 south
İnstalation type	Open space
PV Generator surface	400.1 m 2

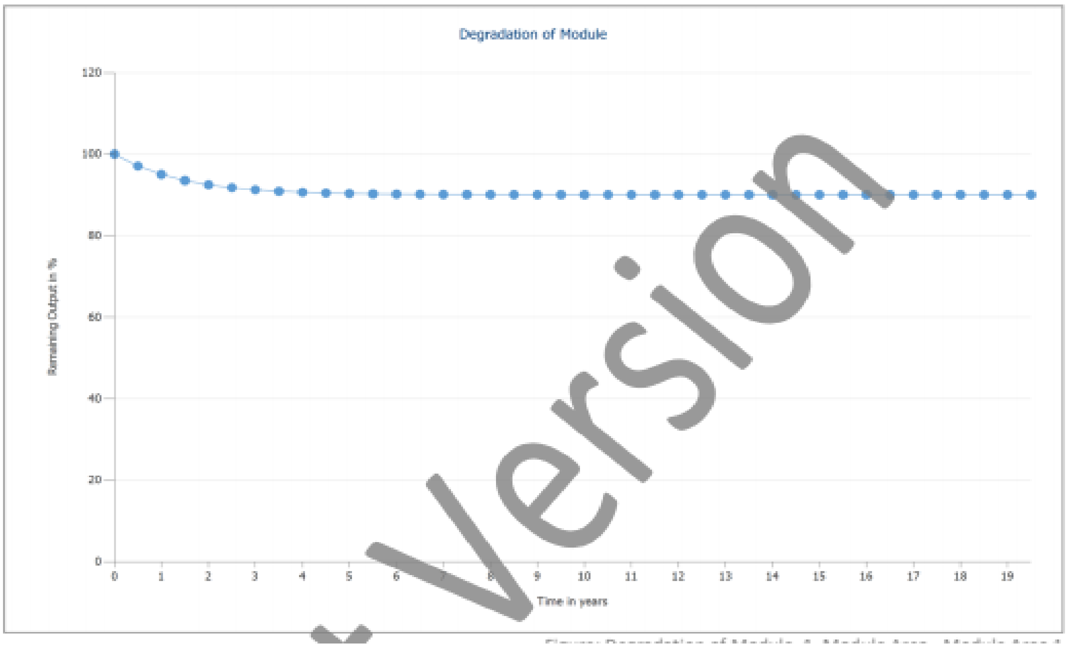


Figure 4.45: Degradation of module

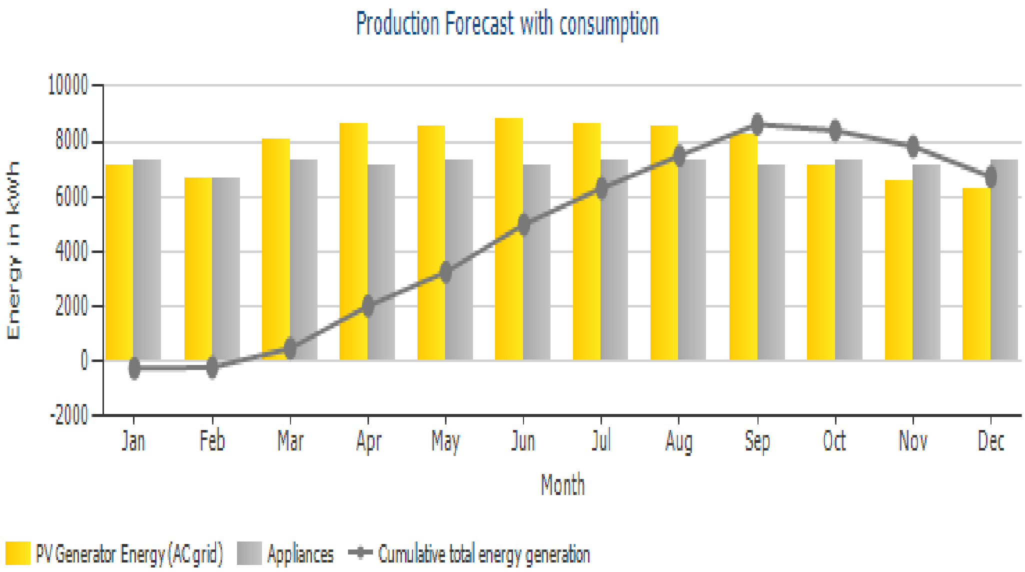


Figure 4.46: Production forcast with consumption

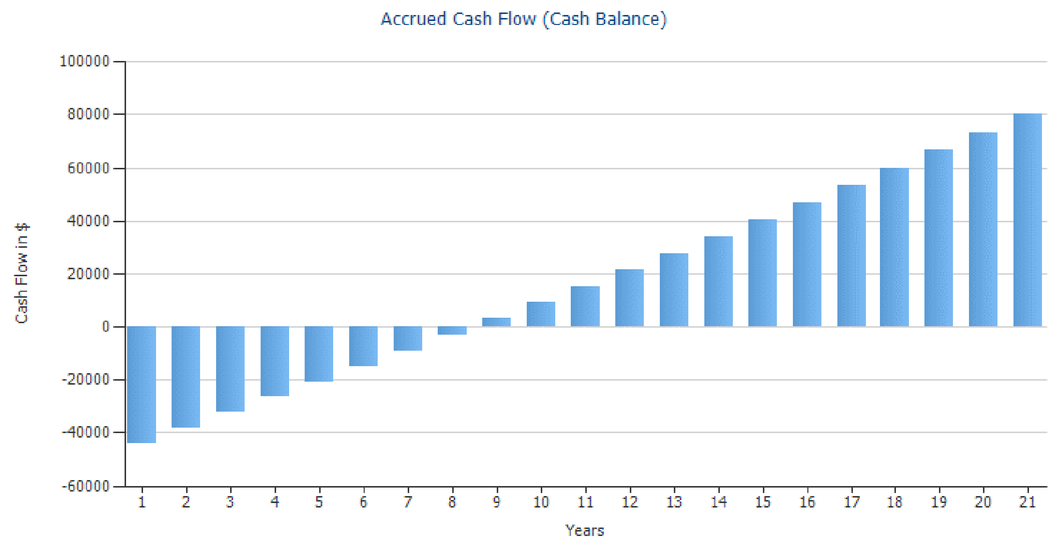


Figure 4.47: Cash Balance

4.4.9 Result& discussion

The energy use in the building was reduced, which led to a reduction in cost according to the proposed scenarios below for each parameters , the details of reduce for each paremeters was shown in the tables (4.2,4.3) below:

Table 4.7: Insight Scenario for reduce EUI

Number	Scenario	Reduce EUI kwh/m2 /year 298.11	Reduce persentage%
1	Building orientation	0	0%
2	Window-to-wall ratio (WWR)	0	0%
3	Windows glass type	0	0%
4	Windows shades	0	0%
5	Wall construction	-32.59	10.93%
6	Roof construction	-12.21	4.09%
7	HVAC System	-88.6	29.72%
9	Infiltration	-4.31	1.44%
10	Lighting Efficiency	-9.49	3.18%
11	Daylighting & Occupancy Controls	-2.84	0.95%
12	Plug Load Efficiency	-9.16	3.07%
13	Operating Schedule	-0.34	0.11%
		-159.54	53.49%

Table 4.8: Insight Scenario for reduce cost

Number of scenario	Scenario Name	Reduce cost $/m2 /year from total cost 19.08	Reduce persentage%
1	Building orientation	0	0%
2	Window-to-wall ratio (WWR)	0	0%
3	Windows glass type	0	0%
4	Windows shades	0	0%
5	Wall construction	-1.22	6.39%
6	Roof construction	-0.34	1.78%
7	HVAC System	-2.98	15.61%
9	Infiltration	-0.14	0.73%
10	Lighting Efficiency	-1.29	6.67%
11	Daylighting & Occupancy Controls	-0.39	2.04%
12	Plug Load Efficiency	-1.23	6.44%
13	Operating Schedule	-0.22	1.15%
SUM		**-7.81**	**40.81%**

Then, the result as shown in the figure below after reduce for all scenarios :

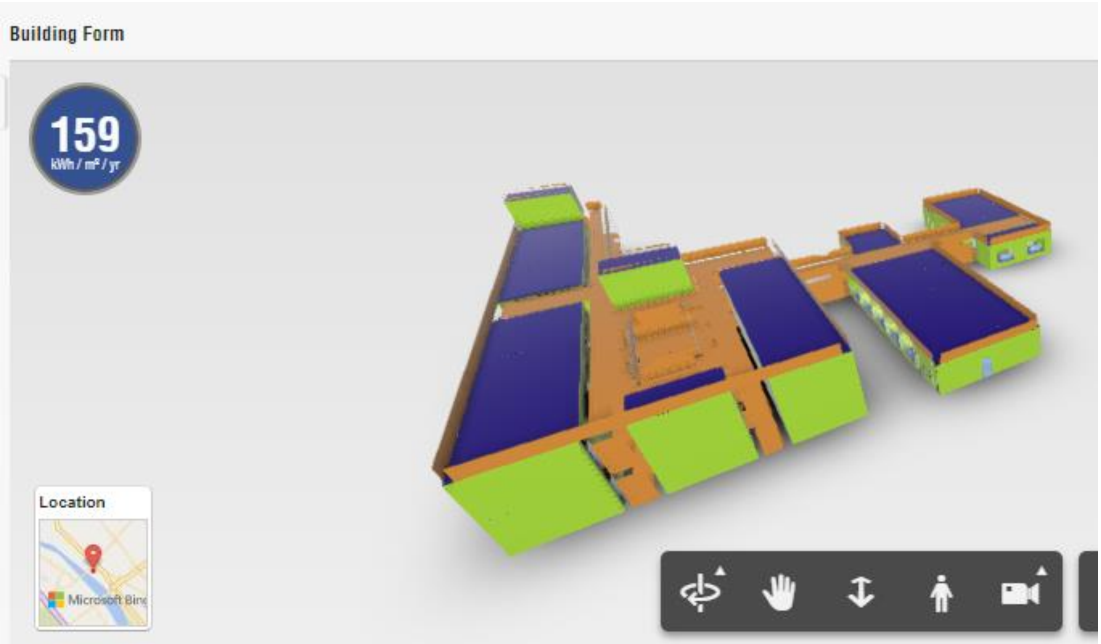


Figure 4.48: After Optimization Options

By using the scenarios proposed by the program, a reduction in the cost and energy of 53 % and 40% respectively is obtained.

We note from the figure 4.48 below for comparing the available scenarios that the options that have the most impact on reducing energy consumption in the building are the cooling system used and operation scheduel.

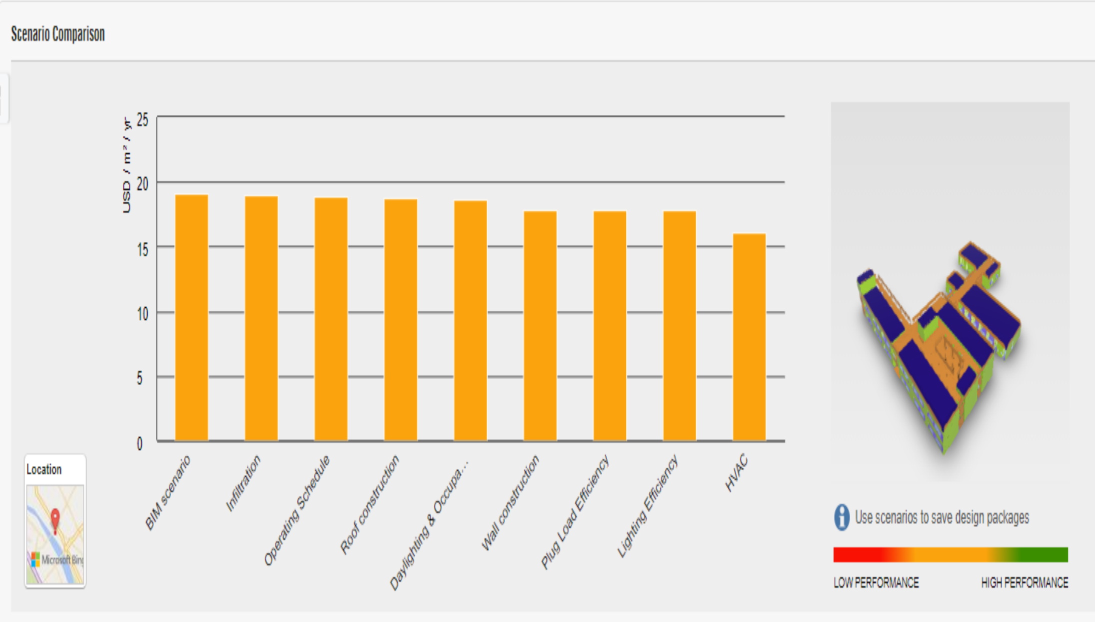


Figure 4.49: Scenarios Comparison

Analysis through the Insight program provides us with formats such as gbxml file that can be imported and used in other tools of energy analysis such as Design Builder sofware

Design builder software

Design-Builder Architectural can be used to improve a building energy performance whether import 3D BIM models or draw them directly into this research modeler. A design builder provides accurate energy, comfort, cost, and daylight performance data to help inform and guide any design decisions or improve building performance. This is done through:

- Flexibility
- Design confidence
- Productivity
- Integrated decision-making
- Daylighting

- Visualization

Architectural simulation packages allow to analyze solar shading, take advantage of renewable technologies, and test facade options in one place while adjusting them to customer requirements.

Technical outputs and high-quality outputs aid in the straightforward and easy-to-understand communication of results to clients. Energy consumption, CO2 emissions, thermal comfort, daylight availability, and cost can all be reduced over the design life of a building, whether it is naturally ventilated or air-conditioned. Engineers and specialist power modeling teams can choose early-stage architectural models for more detailed design and approval work later in the design process thanks to a Design Builder's uniquely adaptable user interface, which allows powerful workflows in many disciplines.

5. CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

To evaluate the impact on its structure's annual energy budget, an existing commercial building located in Baghdad, Iraq was studied. With the help of BIM tools, such as Autodesk Revit and Autodesk Insight, 3D modeling, an energy analysis was carried out on commercial buildings. It is observed that by altering the design strategies, the building becomes energy efficient with a significant decrease in energy consumption. Thus, with the use of this technology, we can reduce life-cycle carbon emissions in the operational phase; this will positively impact and reduce greenhouse gases. Hence, it is essential to design the building before construction after carrying out the energy analysis, this can lead to a huge innovation in the construction sector. for this case study, the building is already there, so options for enhancing the performance of the building were examined after energy analysis. These options are:

- First: The ratio of the wall to the window

As the percentage of WWR goes up, EUI as well as energy cost both increase simultaneously in all directions. Also with the slight increase of the operating schedule, the lighting efficiency, the conduction load efficiency of building both the EUI and the energy cost increase significantly and a huge amount of energy and cost can be reduced. In the building of the case of the study in our research, windows were used with dimensions (120 * 150 cm) and (240 * 150 cm) and for bathrooms 60 * 30 cm. The ratio of the window to the wall, which is three meters high per floor is a large percentage, and the cost of changing it compared to the cost of saving in The energy in the event of replacing all the windows of the building is considered insignificant, so the special windows in the building were not changed.

- Second: The direction of the building

When performing the orientation analysis for any building, we can conclude that by rotating the building between 0° to 360°, the amount of EUI and energy costs differ slightly, and this is insightful in making design decisions, but in our case study, this is not available because the building is standing.

- Third: Heating ventilation and air conditioning system

It is beneficial to use an ASHRAE Package Peripheral Heat Pump (APTHP) and High Efficiency VAV (HEV) to decrease both EUI and energy costs in the building, but its use depends on different factors depending on the area and occupancy and therefore the cost of the change should be examined as the building is existent; and consultation from mechanics experts is helpful regarding this matter. This consultation could also be helpful on separate, economical separate units, because the voltage of the national electricity in Iraq is relatively low, which makes it hard to operate high-voltage refrigeration units.

- Fourth: Window shades

As window height decreases, EUI and energy cost increase slightly in all directions. It was observed through the analysis in the program that the percentage of window shades is very low

- Fifth: The type of glass used

Since the building is a school, the kind of glass used is of the normal type and its percentage is low. It was noted that it has a very slight change through the analysis.

It can be concluded that with the use of the low-emissivity (LOE) type of glass, the amount of EUI and energy cost can be reduced in all directions, but it is very expensive as a material and hence difficult to use for all projects.

- Sixth: Insulation of the walls

By adopting non-insulated wall construction, large amounts of EUI and energy costs increase; and by using 12.25 inch SIP (structural insulated panel) in the building, the EUI and energy cost is insignificant. However, the material cost is very high, so it can sometimes be used in the side of the building, where necessary, to reduce the cost of EUI and energy, to an extent. Similarly, the wall construction can be managed by adopting the non-insulated roof construction with a large amount of EUI and the energy cost is significantly increased. The thermal insulation of the roof of the building of cork or foam can be used to reduce the energy consumption of the building

- Seventh: The lighting used and the lighting sensors

The use of economical LEED lamps can be helpful in decreasing energy costs. Hence, the kind of lamps used in addition to installing a sensor system can reduce energy use in the building.

- Eighth: the number of operating hours

Operating Hours is one of the important options to reduce energy in buildings, but in the case of our building, the number of operating hours was predetermined because the building is a public school and is obligated to fixed working hours

On the whole, we noted that the total changes proposed by the program reduce approximately 53% of the energy consumption in the building, but not all options are readily available. There are options that are hard to achieve because the building exists and not under construction, so the most appropriate option to save energy is the use of solar cells. Since Iraq has a percentage of high radiation and we have enough space on the roof of the building, as well as the government buildings, and working hours are during the day, so it is more appropriate to use solar cells to reduce energy consumption in the building, save energy and recover the cost of the system after 8.3 years of its installation.

Therefore, from the power analysis, it can be concluded that the electrical cost can be significantly reduced by applying this technique.

Hence, reducing the total operating cost of the building as well as carbon emissions which helps the economy and also improves the quality of life for the client and the contractor. To provide beneficial data that can be used to improve the design and performance of a building, BIM technology is essential for design and documentation. It is concluded from the complete energy analysis that this method of energy analysis of a building using Autodesk Revit and Autodesk Insight is the most appropriate and the latest and most efficient technology that helps designers and architects apply various design strategies that were unavailable to them beforehand. Hence, this leads to constructing the building by reducing the cost and time incurred compared to traditional methods that can result in errors in calculations. Although this case study does not cover all service buildings, this is one of the ways using BIM technology can be adopted to decrease carbon emissions and enhance the structure's annual energy budget. A future study can be done on different types of structures with various building envelopes using different BIM tools for energy simulation.

5.2 Recommendations and suggestions

1. Imposing and developing strict laws and legislations to be compatible with the concepts of sustainable development
2. Preparing a government program to support and encourage sustainable projects, by reducing taxes and fines and providing facilities.
3. Launching a government project to prepare a system for evaluating the sustainability of buildings by studying climatic conditions and the local environment and adopting
4. Intensifying studies on building performance analysis tools and supporting and encouraging their use in university institutions.
5. Launching promotional projects that support the trend towards sustainable development.
6. For similar studies, using Design Builder and Autodesk Savary softwares of energy analyses tools is recommended.

REFERENCES

Anna M., Per K. H., Julien S. B., Eike M., Karsten. V., Igor. S., Assunta N. (2011) “Zero Energy Building – A review of definitions and calculation methodologies”. Energy and Buildings, 43(4), pp.971–979.

Aladag, H., 2016. Demirdögen, G.; Isık, Z. Building information modeling (BIM) use in the Turkish construction industry. Procedia Eng, 161, 174–179.

Azhar S., 2011. Building information modeling (BIM): trends, benefits, risks, and challenges for the AEC industry, Leadership, and Management in Engineering, 11 (3): 241–252.

B.R. Zemero, M.E. De Lima Tostes, U.H. Bezerra, V. Dos Santos Batista, C.C.M.M. Carvalho, (2019). Methodology for preliminary design of buildings using multi-objective optimization based on performance simulation, J. Sol. Energy Eng. Trans. ASME 141, 1–12, doi:10.1115/1.4042244.

Bonenberg W. and Wei X., 2015. Green BIM in sustainable infrastructure, Procedia Manufacturing, 3: 1654-1659.

Bradley, A.; Li, H.; Lark, R.; Dunn, S. 2016. BIM for infrastructure: An overall review and constructor perspective. Autom. Construct, 71, 139–152.

Brambilla, N., Komijani, J., Kronfeld, A. S., Vairo, A., (2018). Tumqcd Collaboration. Relations between heavy-light meson and quark masses. Physical Review D, 97(3), 034503.

Cereška, A.; Zavadskas, E.K.; Cavallaro, F.; Podvezko, V.; Tetsman, I.; Grinbergiene, I. 2016. Sustainable assessment ˙ of aerosol pollution decrease applying multiple attribute decision-making methods. Sustainability, 8, 586.

Charef, R.; Alaka, H.; Emmitt, S. 2018. Beyond the third dimension of BIM: A systematic review of literature and assessment of professional views. J. Build. Eng, 19, 242–257.

Cid-López, A.; Hornos, M.J.; Carrasco, R.A.; Herrera-Viedma, E. 2015. A hybrid model for decision-making in the information and communications technology sector. Technol. Econ. Dev. Econ, 21, 720–737.

Davide G.;Bauke de V., (2015), Decision support tool for sustainable renovation projects in Dutch housing corporations, Lausanne, Switzerland,987-992.

Doulos, L. T., Kontadakis, A., Madias, E. N., Sinou, M., & Tsangrassoulis, A. (2019). Minimizing energy consumption for artificial lighting in a typical classroom of a Hellenic public school aiming for near Zero Energy Building using LED DC luminaires and daylight harvesting systems. Energy and Buildings, 194, 201-217.

El Zrelli, R., Courjault-Radé, P., Rabaoui, L., Daghbouj, N., Mansour, L., Balti, R., & Bejaoui, N. (2017). Biomonitoring of coastal pollution in the Gulf of Gabes (SE, Tunisia): use of Posidonia oceanica seagrass as a bioindicator and its mat as an archive of coastal metallic contamination. Environmental Science and Pollution Research, 24 (28), 22214-22225.

Elsheikh, A. H., Guo, J., Huang, Y., Ji, J., & Lee, K. M. (2018). Temperature field sensing of a thin-wall component during machining: Numerical and experimental investigations. International Journal of Heat and Mass Transfer, 126, 935-945.

EPBD recast, (2010). Directive 2010/31/EU of the European Parliament and of the Council of 19 May 2010 on the energy performance of buildings (recast), Official Journal of the European Union, (2010) 18/06/2010.

Gan V. J. L., Deng M., Tse K. T., Chan C. M. and Cheng J. C. P., 2018. Holistic BIM framework for sustainable low carbon design of high-rise buildings, Journal of Cleaner Production, 195: 1091-1104.

Gerrish T., Ruikar K., Cook M., Johnson M. and Lowry C., 2017. BIM application to building energy performance visualisation and management: Challenges and potential, Energy and Buildings, 144: 218-228.

Giouri, E. D., Tenpierik, M., & Turrin, M. (2020). Zero energy potential of a high-rise office building in a Mediterranean climate: Using multi-objective optimization to understand the impact of design decisions towards zero-energy high-rise buildings. Energy and Buildings, 209, 109666.

Gołaszewska, M. and Salamak, M., 2017. Wyzwania w przedmiarowaniu i kosztorysowaniu w technologii bim na przykładzie modelu wiaduktu drogowego. Czasopismo Techniczne, 4/2017.

Guidelines for Digital Construction in Lithuania 2014–2020, (2021). Available online: http://www. skaitmeninestatyba.lt/files/On_development_of_BIM_and_Digital_Construction_Lithuania.pdf (accessed on 23 March 2021).

Habibi S., 2017. The promise of BIM for improving building performance, Energy and Buildings, 153: 525- 548.

Habibi, S.; Obonyo, E.A.; Memari, A.M. 2020. Design and development of energy efficient re-roofing solutions. Renew. Energy, 151, 1209–1219.

Häkkinen, T., & Belloni, K. (2011). Barriers and drivers for sustainable building. Building Research & Information, 39(3), 239-255.

Hergunsel M. F., 2011. Benefits of building information modeling for construction managers and BIM based scheduling, Doctorate, Worcester Polytechnic Institute.

Hermoso-Orzáez, M.J.; Lozano-Miralles, J.A.; Lopez-Garcia, R.; Brito, P. 2019. Environmental Criteria for Assessing the Competitiveness of Public Tenders with the Replacement of Large-Scale LEDs in the Outdoor Lighting of Cities as a Key Element for Sustainable Development: Case Study Applied with Promethee Methodology. Sustainability, 11, 5982. [CrossRef]

Hui, S. C. M., 2018. From BIM to VDC: strategies for innovation and transformation, In Proceedings of the Joint Symposium 2018: Innovative Technology Fusion for Next Challenging Century, 21 Nov 2018 (Wed), Hong Kong. http://ibse.hk/cmhui/JS-2018- SamHui_fullpaper.pdf

Hui, S., 2019. New Opportunities of Using Building Information Modelling (BIM) for Green Buildings. Faculty of Science and Technology, Technological and Higher Education Institute of Hong Kong,.

Hwang, B. G., & Tan, J. S. (2012). Green building project management: obstacles and solutions for sustainable development. Sustainable development, 20(5), 335-349.

Ilhan B. and Yaman H., 2016. Green building assessment tool (GBAT) for integrated BIM-based design decisions, Automation in Construction, 70: 26-37.

J. Carreras, D. Boer, L.F. Cabeza, L. Jiménez, G. Guillén-Gosálbez, 2016. Eco-costs evaluation for the optimal design of buildings with lower environmental impact, Energy Build. 119 (2016) 189–199, doi:10.1016/j.enbuild.2016.03.034.

Jalaei F. and Jrade A., 2015. Integrating building information modeling (BIM) and LEED system at the conceptual design stage of sustainable buildings, Sustainable Cities and Society, 18: 95-107.

Joris P. v. H., Upscaling net zero energy retrofit concepts for high-rise buildings, MSc thesis, Construction Management and Engineering, Eindhoven University of Technology, Netherlands,2020.

Karunathilake, H., Hewage, K., Brinkerhoff, J., & Sadiq, R. (2019). Optimal renewable energy supply choices for net-zero ready buildings: A life cycle thinking approach under uncertainty. Energy and Buildings, 201, 70-89.

Kolokotsa D., Rovas D., Kosmatopoulos E.and Kalaitzakis K.,(2011). A Roadmap towards intelligent net zero- and positive-energy buildings. Solar Energy, 85, 67- 84.

Korzun, A. M., Nielsen, E. J., Walden, A. C., Jones, W. T., Carlson, J. R., Moran, P. J., ... & Sandstrom, T. A. (2020). Effects of Spatial Resolution on Retropropulsion Aerodynamics in an Atmospheric Environment. In AIAA Scitech 2020 Forum (p. 1749).

Kota S., Haberl J. S., Clayton M. J. and Yan W., 2014. Building Information Modeling (BIM)-based daylighting simulation and analysis, Energy and Buildings, 81: 391-403.

Ksi ˛azek, M.V.; Nowak, P.O.; Kivrak, S.; Rosłon, J.H.; Ustinovichius, L. 2015. Computer-aided decision-making in ˙ construction project development. J. Civil Eng. Manag, 21, 248–259.

Kulasekara G., Jayasena H.S., Ramadewa K.A.T.O., 2013. Comperative Efectiveness of Quantity Surveying in a Building Information Modelling Implementation, The Second Wolrd Construction Symposium 2013: Socio-Economic Sustainability In Construction 14–15 June, Colombo 2013, Sri Lanka.

L. Aelenei, D. Aelenei, H. Goncalves, R. Lollini, E. Musall, A. Scognamiglio, E. Cubi, M. Noguchi, (2013). Design issues for net zero-energy buildings, Open House Int. 38 (3) 7–14.

L. Jagemar, M. Schmidt, F. Allard, P. Heiselberg, J. Kurnitski, (2011). Towards nZEB-some examples of national requirements and roadmaps, Carbon 60 (80) 100

L. Peruzzi, F. Salata, A. De Lieto Vollaro, R. De Lieto Vollaro, 2013. The reliability of technological systems with high energy efficiency in residential buildings, Energy Build. 68 (2014) 19–24, doi:10.1016/j.enbuild.2013.09.027.

Lin, Y.-C.; Lee, H.-Y.; Yang, I.-T. 2016. Developing as-built BIM model process management system for general contractors: A case study. J. Civil Eng. Manag, 22, 608–621

Lindblad, H.; Guerrero, J.R. 2020. Client’s role in promoting BIM implementation and innovation in construction. Constr. Manag. Econ., 38, 468–482. [CrossRef]

Liu Z., Chen K., Peh L. and Tan K. W., 2017. A feasibility study of Building Information Modeling for Green Mark New Non-Residential Building (NRB): 2015 analysis, Energy Procedia, 143: 80-87.

Liu, S.; Shin, Y. C. (2019). Additive manufacturing of Ti6Al4V alloy: A review. Materials & Design, 164, 107552.

Love Peter, E.D.; Matthews, J.; Simpson, I.; Hill, A.; Olatunji, O. A. 2014. A benefits realization management building information modeling framework for asset owners. Autom. Construct, 37, 1–10. [CrossRef]

Lu Y., Wu Z., Chang R. and Li Y., 2017. Building Information Modeling (BIM) for green buildings: A critical review and future directions, Automation in Construction, 83: 134-148.

Louise W.; Behzad R.; Lu A., (2018), A review of Net Zero Energy Buildings with reflections on theAustralian context, Energy and Buildings,158:616-628.

Maltese S., Tagliabue L. C., Cecconi F. R., Pasini D., Manfren M. and Ciribini A. L. C., 2017. Sustainability assessment through green BIM for environmental, social and economic efficiency, Procedia Engineering, 180: 520-530.

Mark Z. Jacobson , Vijaysinh Jadhav 2018 . World estimates of PV optimal tilt angles and ratios of sunlight incident upon tilted and tracked PV panels relative to horizontal panels

Miettinen, R.; Paavola, S. 2014. Beyond the BIM utopia: Approaches to the development and implementation of building information modeling. Autom. Construct., 43, 84–91. [CrossRef]

Mirzaei, A.; Nasirzadeh, F.; Jalal, M.P.; Zamani, Y. 2018. 4D-BIM Dynamic Time–Space Conflict Detection and Quantification System for Building Construction Projects. J. Constr. Eng. Manag., 144, 04018056.

Natephra W., Yabuki N. and Fukuda T., 2018. Optimizing the evaluation of building envelope design for thermal performance using a BIM-based overall thermal transfer value calculation, Building and Environment, 136: 128- 145.

P. Singh, R. Verma, (2014). Zero-Energy buildings-A review, SAMRIDDHI- J. Phys. Sci. Eng. Technol. 5 (2) (2014) 143–150, http://dx.doi.org/10.18090/samriddhi. v5i2.1532.

Petri, I.; Beach, T.; Rana, O.F.; Rezgui, Y. 2017. Coordinating multi-site construction projects using federated clouds. Autom. Construct, 83, 273–284.

Pučko, Z., Nataša, N. and Klanšek, U., 2014. Building Information Modeling Based Time And Cost Planning In Construction Projects. Organization, technology and management in construction: An international journal, 6(1).

Pučko, Z., Vincek, D., Štrukelj, A. and Šuman, N. (2017). Application of 6D Building Information Model (6D BIM) for Business-storage Building in Slovenia. IOP Conference Series: Materials Science and Engineering, 245, p.062028.

Santos R., Costa A. A., Silvestre J. D. and Pyl L., (2019a). Informetric analysis and review of literature on the role of BIM in sustainable construction, Automation in Construction, 103: 221-234.

Santos R., Costa A. A., Silvestre J. D. and Pyl L., (2019b). Integration of LCA and LCC analysis within a BIMbased environment, Automation in Construction, 103: 127-149.

Sartori, J. Candanedo, S. Geier, R. Lollini, A. Athienitis, F. Garde, L. Pagliano, 2010. Comfort and Energy Performance Recommendations for Net Zero Energy Buildings, the Proceedings of EuroSun.

Say, N.P.,Yücel, M., (2006), Energy consumption and CO2 emissions in Turkey: empirical analysis and future projection based on an economic growth. Energy Policy, 34: 3870-3876.

Shady A., Polyvios E.l Flouris X., Rodolphe M.,Christophe M., Vasilis K., Maria B.,Iakovos K., Lorenzo P., Maurizio C.,Manuela A., Marco F., Tudor B., Viorel B.,Ruxandra C., Juan M., Hidalgo-B., (2017), Overview and future challenges of nearly zero energy buildings(nZEB) design in Southern Europe, Energy and Buildings ,155:439-458.

Shen Z., Issa R.R.A., 2010. Quantitative evaluation of the BIM-assisted construction detailed cost estimates, “Journal of Information Technology in Construction” (ITcon), Vol. 15, 234–257.

Singh P. and Sadhu A., 2019. Multicomponent energy assessment of buildings using building information modeling, Sustainable Cities and Society, 49, Article 101603.

SMACNA, 2017. Virtual Design and Construction in Practice: Benefits, Challenges, and Proven Strategies for AEC Teams, White Paper, Sheet Metal and Air Conditioning Contractors' National Association (SMACNA), Chantilly, Virginia. https://www.smacna.org/resources/resource/2017/11/08/ new-virtual-design-and-construction-white-paper.

Soytas U., Ramazan S., (2007), Energy consumption, economic growth, and carbon emissions: Challenges faced by an EU candidate member, Ecological Economics 68(6):1667-1675.

Sridharan, kk. (2016). Process to convert an existing building into zero energy building (ZEB) in 3 cities (London,Patras and Chennai): comparative results pdf. p.101.

Sultan Ç. Ö., Net-Zero Energy Renovations of High-Rise Apartments, MSc thesis, Built Environment, Eindhoven University of Technology, Netherlands,2018.

Tulenheimo, R. 2015. Challenges of implementing new technologies in the world of BIM: Case study from construction engineering industry in Finland. Procedia Econ. Finance, 21, 469–477.

Turkish Ministry of Environment, Urbanisation and Climate Change. (2020), Nearly zero energy for buildings (NSEB)

Ürge-Vorsatz, D., Khosla, R., Bernhardt, R., Chan, Y. C., Vérez, D., Hu, S., & Cabeza, L. F. (2020). Advances toward a net-zero global building sector. Annual Review of Environment and Resources, 45, 227-269.

US DOE, (2010). Building Technologies Program, Planned Program Activities for 2008–2012, Department Of Energy, US. http://www1.eere.energy.gov/buildings/mypp.html , 2008 (downloaded 01/07/2010).

Van den Heiligenberg, J. P. (2020). Upscaling net zero energy retrofit concepts for high-rise buildings.

Wang H., Pan Y. and Luo X., (2019). Integration of BIM and GIS in sustainable built environment: A review and bibliometric analysis, Automation in Construction, 103: 41-52.

WEF, (2018). Shaping the Future of Construction: An Action Plan to Accelerate Building Information Modeling (BIM) Adoption, World Economic Forum (WEF) in collaboration with The Boston Consulting Group, Cologny/Geneva, Switzerland. http://www3.weforum.org/docs/WEF_Accelerating_BIM_Adoption_Action_Plan.pdf

Wang Y., Lili C., (2016), The relationship between urbanization, energy use and carbon emissions: Evidence from a panel of Association of Southeast Asian Nations (ASEAN) countries, Journal of Cleaner Production,112: 1368-1374.

Wong J. K. W. and Zhou J., 2015. Enhancing environmental sustainability over building life cycles through green BIM: A review, Automation in Construction, 57: 156- 165.

Wong, K. D., & Fan, Q. (2013). Building information modelling (BIM) for sustainable building design. Facilities, 31(3/4), 138-157.

Yan, H.; Damian, P. (2008). Benefits and Barriers of Building Information Modelling. In Proceedings of the 12th International Conference on Computing in Civil and Building Engineering, Beijing, China, 16–18 October 2008.

Zhang, J.; Seet, B.-C.; Lie, T.T. (2015).Building information modelling for smart built environments. Buildings, 5, 100–115.

Zolfani, S.H.; Maknoon, R.; Zavadskas, E.K. 2016. Multiple attribute decision making (MADM) based scenarios. Int. J. Strat. Property Manag, 20, 101–111.

Zuo, J., & Zhao, Z. Y. (2014). Green building research–current status and future agenda: A review. Renewable and Sustainable Energy Reviews, 30, 271-281.

Zuo, J.; Zillante, G.; Xia, B.; Chan, A.; Zhao, Z. 2015. How Australian construction contractors responded to the economic downturn. Int. J. Strat. Property Manag, 19, 245–259.

RESUME

PROFESSIONAL EXPERIENCE

2013-2019 Ministry of higher education &scientific research

Work in the field of scientific research.

2013-2011 Ministry of construction &Housing/Baghdad

Work in the field of preparing bills of quantities.

2009-2011 Ministry of construction &Housing/Sulaymanya

Work in preparing work progress schedules.

2007-2009 Lama company /Siyria

Work in the field of direct supervision of projects and drawing on AutoCAD program.

COMPUTERS

AUTOCAD	100%
REVIT	75%
MS-PROJECT	75%
PRIMAVERA	70%
WINDOWS	90%
OFFICE	90%

TRAINING

2007	PRIMAVERA COURES
2009	PLAN SWIFT
2010	GOOGLE SKETCH
2013	PMP

LANGUAGES

ARABIC	100%
ENGLISH	80%
TURKISH	50%

HOBBIES

I am a tennis player and have won many local championships while possessing coaching skills.

Currently a master's student in Gedik university (Engineering management program) and I work my thesis in BIM program (Revit&Insight) research has been done on programs.