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ORIGINAL ARTICLE

Adoption of BIM technology to develop sustainable buildings in the Iraqi construction sector

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Abstract

Objectives: This study aims to identify and assess sustainable design parameters based on the tools and strategies provided by Building Information Modeling (BIM)technology to improve building sustainability. **Method:** This study idea was applied to one of the Iraqi construction projects in Diyala province, to achieve the aim of this study, we collected real data (CAD drawings, schedule of quantities) by an interview with professional engineers in the construction fields and after this, the project is simulated by using Autodesk Revit 2018 software. **Findings:** We made analysis and found the results of analysis by using Autodesk Insight360 Cloud added to Revit2018 that illustrate design parameters and its effect on energy use intensity. The use of BIM technology helps designers and architects to identify and assess sustainable design parameters in the early design stage that lead to improving the sustainability of the building. **Applications:** BIM technology is one of the modern and important technologies in the construction sector. Adopting BIM technology is very useful to develop sustainable buildings in the construction sector.

Keywords: BIM; Autodesk Revit 2018; Autodesk Insight360 cloud; Sustainable design options; Energy use intensity

1 Introduction

The construction sector is considered one of the main contributors to the environmental impact due to its high energy consumption which has led to rising demand for sustainable buildings [1,2]. Iraqi energy stations depend mainly on fossil fuels for energy generation, which has negatively affected on environment and citizens [3]. in Iraq, the deficit in meeting energy demand in 2003 around 27%, due to the high energy consumption, wars, and economic devastation [4]. In recent years, the world is witnessing an increase in awareness towards the improvement of energy efficiency in construction [5,6]. More effective decisions can be made related to the design of sustainable buildings in the early stages of design and construction. Traditional CAD method does not have the ability to make such decisions in the early design stage [7]. Building Information Modeling(BIM) has become an effective solution that can improve many aspects of

the construction industry[8]. BIM technology can be applied to achieve many aspects of sustainable design, such as building orientation, daylight performance, energy analysis, building envelope, etc.[9]. BIM is a technology that has the ability to do simulations of reality, which helps to solve all problems related to the project in the early design stage[10]. BIM includes a set of computer applications that increase the efficiency of a construction project's performance during its life cycle[11,12]. In recent years, there has been a lot of research that has adopted BIM technology for different aspect in the Iraqi construction sector such as safety analysis[13], quantities Takeoff[14], energy analysis[15]

There is a lot of research on the use of BIM technology in the sustainability domain[7], investigated the benefits of BIM technology for sustainability analyses. The researcher found that BIM technology was very helpful for designers and architects in sustainable design. In[16] studied the effect of various alternatives and design solutions to reduce energy consumption by using BIM technology. In the end, the researcher suggested some alternatives. In[17] investigated the possibility of applying BIM in the Middle East and how to benefit from the advantages that BIM technology provides to support sustainable concepts. The researcher adopted the questionnaire approach where results illustrate that of the respondents currently use BIM technology in their projects and that around three-quarters of respondents adopt sustainable concepts.[18] Studied various design standards (exterior walls material, roofs material, and a set of window-to-wall ratios) to enable architects and designers to use software to enable the process of sustainable use of energy in buildings. The researcher found through results around 15% improvement in the energy consumption due to change design options such as window to wall ratio[19], studied the effect of different green envelops on energy efficiency and consumption. The researcher found through results double-glazed windows contribute to the most significant reduction of energy consumption.

In recent years, the construction sector in Iraq suffers from many problems related to the high energy consumption, which have negatively affected the environment where designers and architects relied on traditional methods based on 2D schemes and the experience. Through this study, the authors try to find the various strategies and tools offered by BIM technology to improve the sustainability of building in the early design stage.

2 Research Methodology and Case Study

In this part, the authors explain the methodology of this study in addition to that the case study will be clarified.

2.1 Methodology

In this study, the research methodology aims to identify tools and strategies that help in sustainable design and increase energy efficiency by adopting BIM technology. Figure 1 shows a framework of methodology. To achieve methodology objectives, these steps are followed:

1. Select case study and collect information related to project (CAD drawing, schedules quantities.
2. Create 3D BIM model of Project by using Autodesk Revit2018 as shown in Figure 3.
3. Create spaces for all rooms as shown in Figure 2.
4. Change energy setting and import some information such as location of the project, type of project.
5. Generate energy model as shown in Figure 2, and select optimize panel in Rivet 2018 to run energy analysis in Insight360 cloud.
6. Energy analysis and the result shows in Autodesk Insight 360 cloud.
7. The results of the analysis give the various components of design element and their impact on energy use intensity (EUI).
8. Illustrate and assess sustainable design parameters which increase energy efficiency in Autodesk Insight360 cloud

2.2 Case study

For this study, educational building (Deanship Building of Agriculture College) in Diyala province was adopted as a case study. The total area of the project is (2924m^2). Other information around the project summarized as following:

- Start date: May 2010
- This project was stopped in 2011, work on it started again in 2013
- End date: April 2018
- Estimated cost: 1,693,308,500 ID
- It contains two floors with a height of 3.65m for each floor.
- Material for all walls is bricks and material for all roof is concrete.

Figure 3 shows 3D model in Revit2018 of case study.

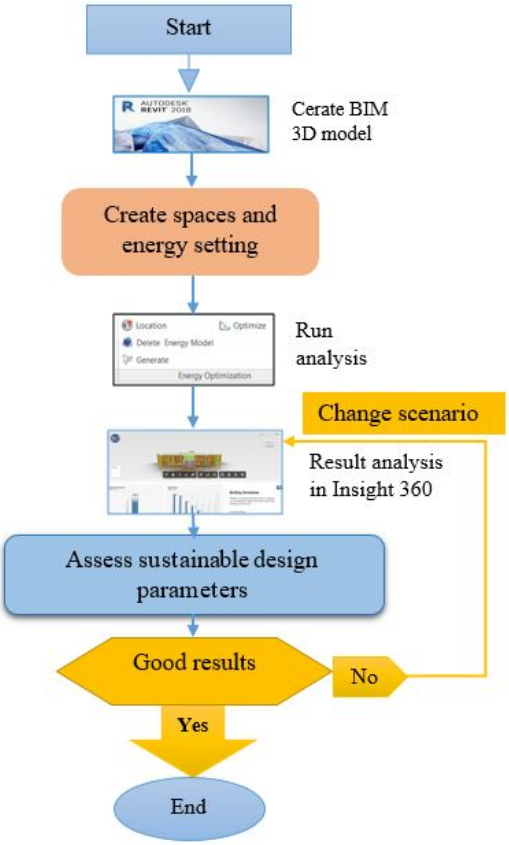

Fig 1. Framework of methodology

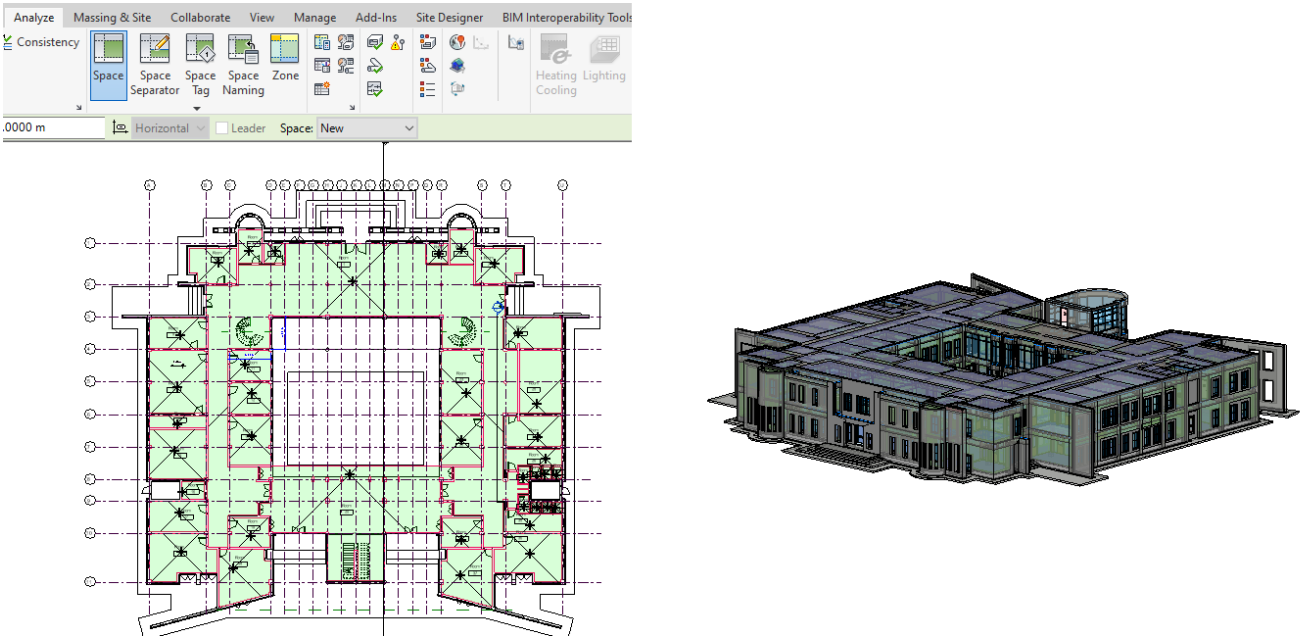

Fig 2. Spaces and energy model of the case study

Fig 3. 3D model of case study

3 Results and Discussion

The results of this study depend on energy settings in Revit 2018 and on the scenario is selected in Autodesk Insight 360 cloud. Figure 4 illustrate 3D model in Insight 360 cloud.

Results illustrated the following:

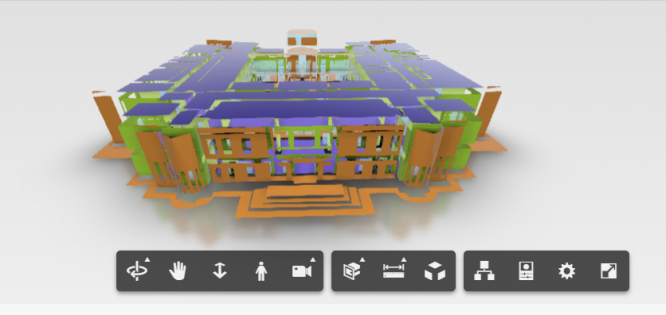

Fig 4. 3D model in Insight360

3.1 Building orientation

Building orientation is taken into consideration because it has an important role in reducing energy consumption, improve indoor environmental quality, analysis in insight360 helps designers and architects to find the suitable orientation of building for reduced energy consumption. Figure 5 shows the 315 degrees' orientation is the most effective than other orientations on energy consumption where reduced energy use intensity around 5.24 kWh / m^2 / year.

3.2 Window-to-wall ratio (WWR)

The window-to-wall ratio is taken into consideration because it has an important role in reducing energy consumption. Figure 6 shows uses window to wall ratio (15%) in southern walls reduced energy use intensity around 0.71kWh/m^2/year as well as uses window to wall ratio (9%) in Northern walls reduced energy use intensity around 1.78 kWh/m^2/year. From Figure 6 window to wall ratio in northern walls is more effect on energy use intensity than window to wall ratio in southern walls where should be reduced window to wall ratio in northern walls in building design.

Figure 7 shows window to wall ratio (15%) in western walls reduced energy use intensity around 5.04 kWh/m2/year as well as window to wall ratio (15%) in eastern walls reduced energy use intensity around 1.26 kWh/m^2/year. Figure 7 shows that the east walls are more sensitive to variation in the window to wall ratio as compared to west walls, to use sunlight for artificial lighting, higher window to wall ratio for west walls can be used while keeping window to wall ratio lower for east walls.

Fig 5. Building orientation

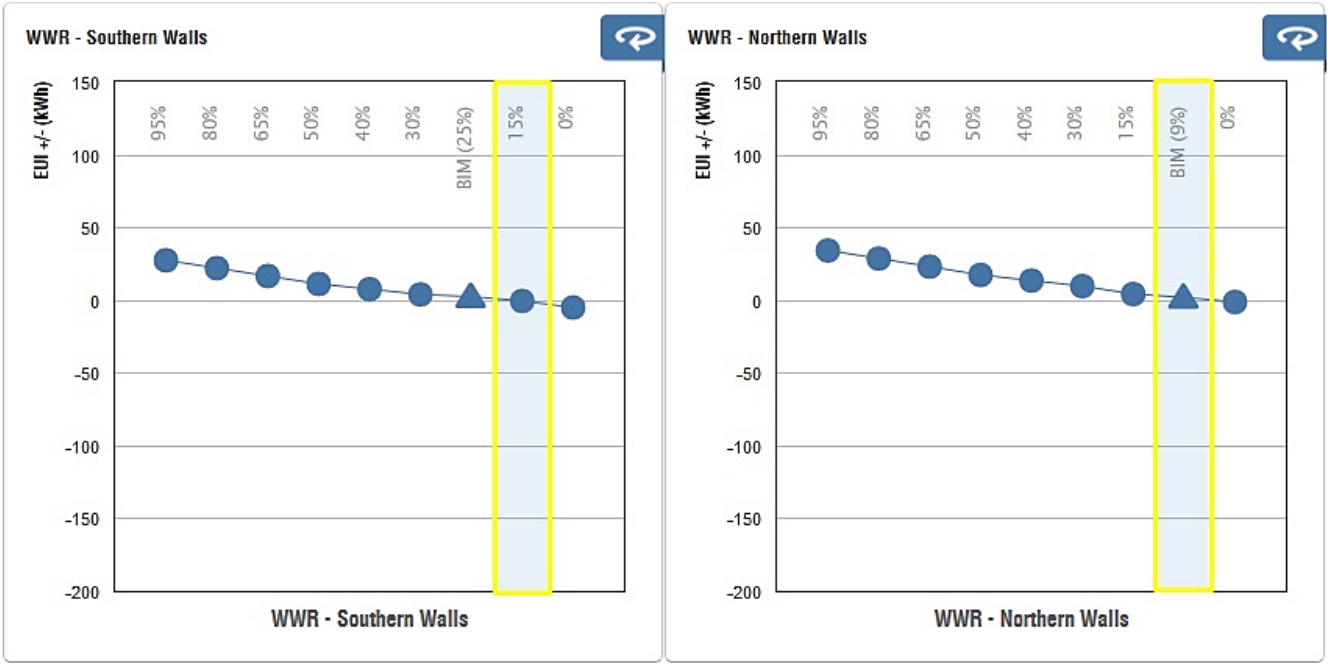

Fig 6. WWR in southern and northern walls

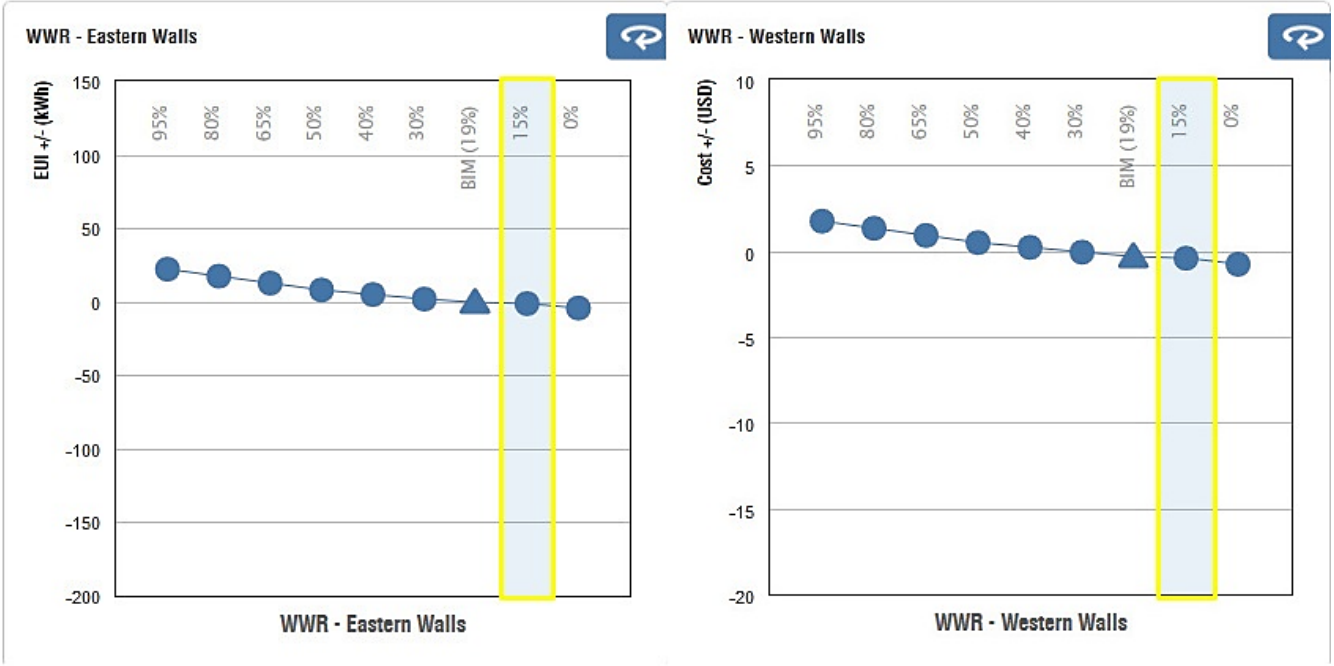

Fig 7. WWR in western and eastern walls

3.3 Window glass type

In the design of the building, glass type is taken into consideration because it has an important role in reducing energy consumption. Figure 8 shows use triple Low-E glass in windows of south walls reduced energy use intensity around 4.06kWh/m^2/year as well as use triple Low-E glass in windows of north walls reduced energy use intensity around 0.25 kWh/m^2/year. Figure 8 shows that all types of glass are convergent in terms of their effect on energy use intensity.

Figure 9 shows use of triple Low-E glass in windows of west walls reduced energy use intensity around 6.27 kWh/m^2/year as well as use triple Low-E glass in windows of east walls reduced energy use intensity around 2.88 kWh/m^2/year. Figure 9 shows that all types of glass are convergent in terms of their effect on energy use intensity well as using single glass that increases energy use intensity.

3.4 Wall construction

In the design of the building, wall type is taken into consideration because it has a major role in reducing energy consumption. Figure 10 shows different types of sustainable walls for building and shows the extent of their impact on the energy use intensity, according to analysis if use IFC wall (insulated concrete form) reduced energy use intensity about 9.06kwh / m^2/ year. Figure 10 shows the importance of insulation in the walls because it works to increase the thermal resistance of the wall which has a high effect on energy consumption.

3.5 Roof construction

This analysis shows different types of insulation and shows the extent of their impact on energy use intensity. Figure 11 shows that energy use intensity is affected by thermal insulation rating used in the roof, where the best value can be obtained when the insulation rating is R60 where reduced energy use intensity around 2.17 kwh/m^2/year.

3.6 HVAC System

HVAC system is one of the main components of energy usage, HVAC system effects on indoor air quality and air temperature of the building. Figure 12 shows a different type of HVAC system and the effect on energy use intensity. Figure 12 shows a package terminal heat pump(PTHP) that decrease the energy use intensity of about49.70 kw/m^2/year.

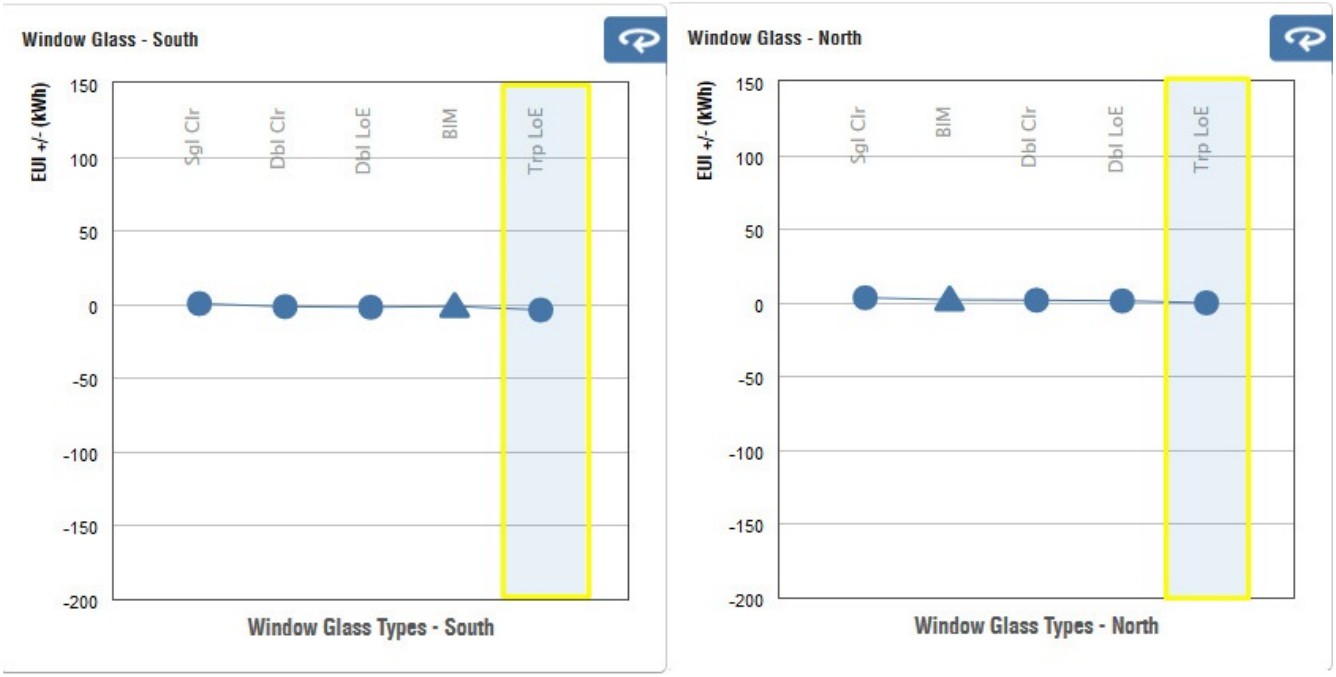

Fig 8. Windows glass type in south and north walls

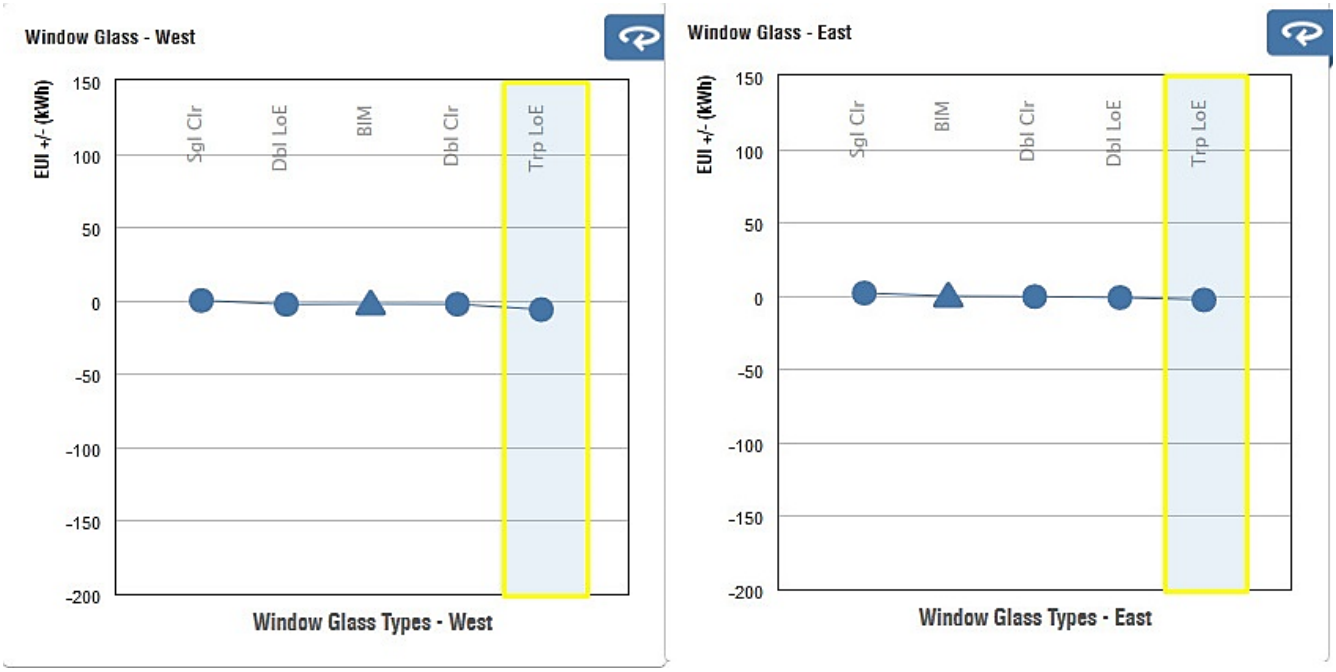

Fig 9. Windows glass type in west and east walls

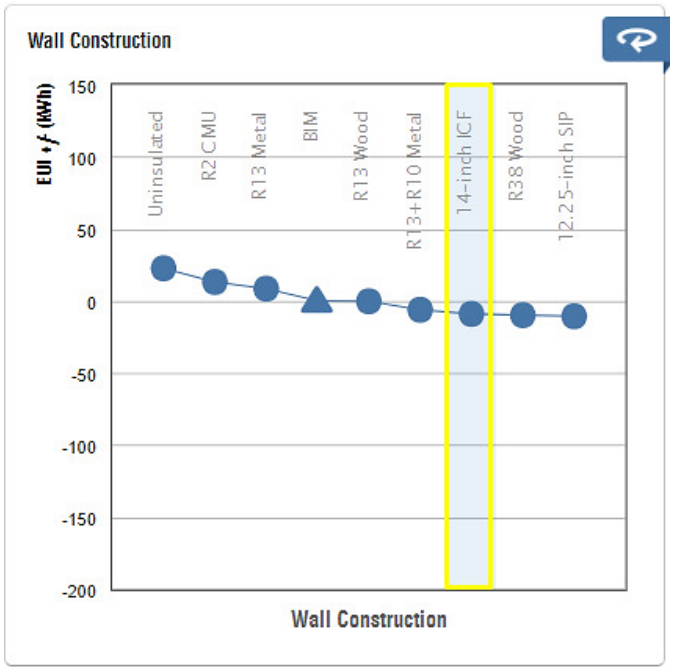

Fig 10. Wall construction type

Fig 11. Roof construction type

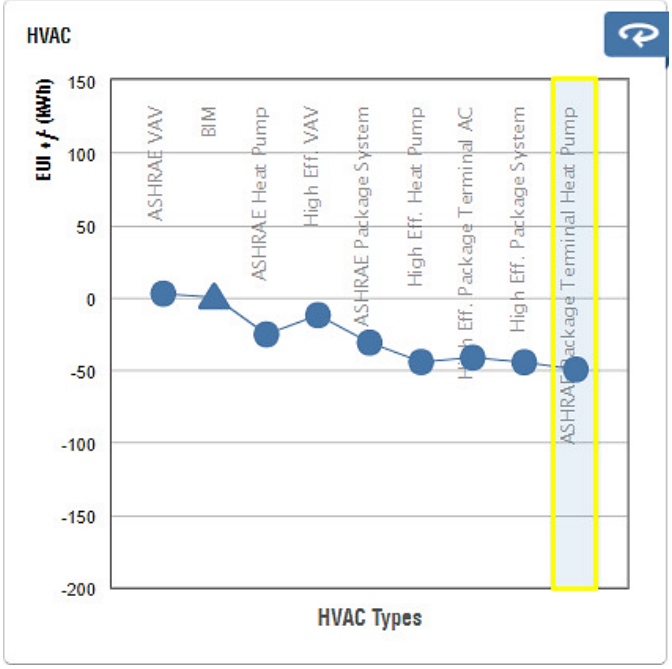

Fig 12. HVAC System types

3.7 Photovoltaic PV panels

The panels are considered one of the most important sources in the world for renewable energy generation by taking advantage of solar energy, insight 360 analysis allows knowing the effect of the use of PV panels on energy use intensity. Figure 13 shows PV panels have a high effect on energy use intensity where reduced energy use intensity around 113 kwh/m^2/year.

Figure 14 shows a model history of design options according to scenario selected, the most design parameters have a major effect on reducing energy use intensity are PV panels, HVAC system, walls type, orientation. This gives designers at early design stage indication to the most design parameters that effect on energy consumption.

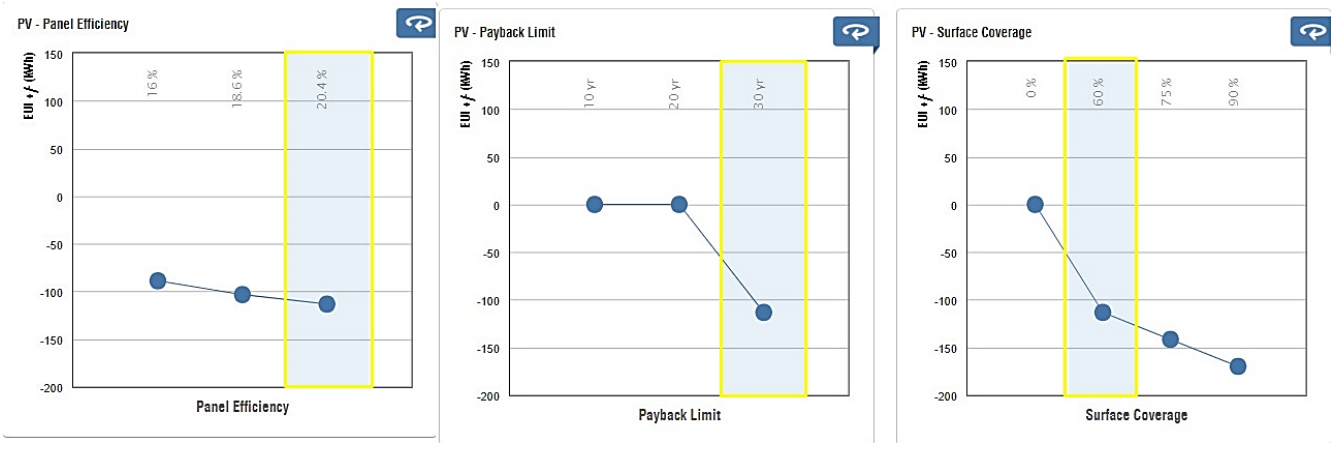

Fig 13. PV panels effect

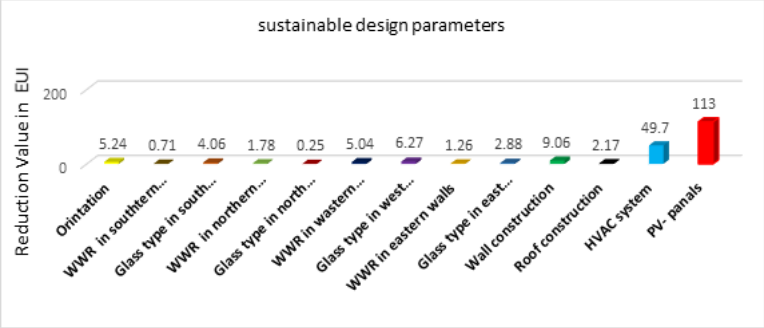

Fig 14. A model history of design parameters

4 Conclusion

The process of identifying and assessing sustainable design parameters during the design phase is very difficult for designers and architects because of their dependence on traditional methods based on two-dimensional schemes and expertise. This study aims to find the best tools and strategies provided by BIM technology to identify and evaluate the best sustainable design parameters during the early design stage to improve building sustainability. Based on the results, the authors conclude the following:

• Use of Autodesk Insight360 cloud based on BIM technology is very suitable for identify design parameters that increase the sustainability of the building during its life cycle.

• Use of Autodesk Insight360 cloud based on BIM technology helps in assessing the effect of different design parameters on energy consumption and thus helps designers and architects find more energy-efficient design parameters. Results illustrate PV panels is the most effect on energy use intensity that reduce energy use intensity around (113kWh/m^2/year).

• Use of Autodesk insight 360 cloud based on BIM technology gives a clear idea around design elements that have a significant impact on building energy. Results illustrate the most design parameters have a major effect on reducing energy use intensity are PV panels, HVAC system, walls type, orientation.

• Limitation of this study in the early design stage.

• For futures studies: using BIM technology to develop sustainability concept of infrastructure.

References

1) Bribián IZ, Usón AA, Scarpellini S. Life cycle assessment in buildings: State-of-the-art and simplified LCA methodology as a complement for building certification. *Building and Environment*. 2009;44(12):2510–2520. doi:10.1016/j.buildenv.2009.05.001.
2) Carvalho JP, Bragança L, Mateus R. Optimising building sustainability assessment using BIM. *Automation in Construction*. 2019;102:170–182. doi:10.1016/j.autcon.2019.02.021.
3) Mahdi AM, Reza KS, Kadhem JA, Al-Waeli AA, Al-Asadi AHK. The effect of Iraqi climate variables on the performance of photovoltaic modules. *The effect of Iraqi climate variables on the performance of photovoltaic modules*. 2017;15:17–17. Available from: http://un.uobasrah.edu.iq/papers/4743.pdf.
4) Kazem HA, Chaichan MT. Status and future prospects of renewable energy in Iraq. *Renewable and Sustainable Energy Reviews*. 2012;16(8):6007–6012. doi:10.1016/j.rser.2012.03.058.
5) Li Y, Zhu N, Qin B. What Affects the Progress and Transformation of New Residential Building Energy Efficiency Promotion in China: Stakeholders' Perceptions. . *Energies*. 2019;12(6):1027. doi:10.3390/en12061027.
6) Ballarini I, Luca GD, Paragamyan A, Pellegrino A, Corrado V. Transformation of an Office Building into a Nearly Zero Energy Building (nZEB): Implications for Thermal and Visual Comfort and Energy Performance. *Energies*. 2019;12(5):895. doi:10.3390/en12050895.
7) Azhar S, Brown J. BIM for Sustainability Analyses. *International Journal of Construction Education and Research*. 2009;5(4):276–292. doi:10.1080/15578770903355657.
8) Abanda FH, Byers L. An investigation of the impact of building orientation on energy consumption in a domestic building using emerging BIM (Building Information Modelling). *Energy*. 2016;97:517–527. doi:10.1016/j.energy.2015.12.135.
9) Krygiel E, Nies BG. BIM: successful sustainable design with building information modeling. John Wiley & Sons. 2008.
10) Abed HR, Hatem WA, Jasim NA. Role of BIM technology in enhancing safety analysis of Iraqi oil projects. *Asian Journal of Civil Engineering*. 2020;21(4):695–706. doi:10.1007/s42107-020-00231-5.
11) Hatem WA, Abd AM, Abbas NN. Barriers of Adoption Building Information Modeling (BIM) in Construction Projects of Iraq. *Engineering Journal*. 2018;22(2):59–81. doi:10.4186/ej.2018.22.2.59.
12) Hatem WA, Kwan A, Miles J. Comparing the effectiveness of face to face and computer mediated collaboration. *Advanced Engineering Informatics*. 2012;26(2):383–395. doi:10.1016/j.aei.2012.01.001.
13) Abed HR, Hatem WA, Jasim NA. Adopting BIM Technology in Fall Prevention Plans. *Civil Engineering Journal*. 2019;5(10):2270–2281. doi:10.28991/cej-2019-03091410.

14) Abd AM, Khamees AS. BIM as Evaluation Tool for Existing Building Energy and Quantities Takeoff. *Civil Engineering Journal*. 2018;3(12):1247–1247. doi:10.28991/cej-030954.
15) Naji HI, Mahmood M, Mohammad HE. Using BIM to propose building alternatives towards lower consumption of electric power in Iraq. *Asian Journal of Civil Engineering*. 2019;20(5):669–679. doi:10.1007/s42107-019-00134-0.
16) Shoubi MV, Shoubi MV, Bagchi A, Barough AS. Reducing the operational energy demand in buildings using building information modeling tools and sustainability approaches. *Ain Shams Engineering Journal*. 2015;6(1):41–55. doi:10.1016/j.asej.2014.09.006.
17) Mahjoob A, Abed MM. Assessing BIM integration with sustainable requirement for buildings construction. *International Journal of Science and Research (IJSR)*. 2015;6:2258–65.
18) Najjar MK, Tam VWY, Gregorio LTD, Evangelista ACJ, Hammad AWA, Haddad A. Integrating Parametric Analysis with Building Information Modeling to Improve Energy Performance of Construction Projects. *Energies*. 2019;12(8):1515–1515. doi:10.3390/en12081515.
19) Ariff AAA, Ahmad SS, Hussin MA. Green envelope as an architectural strategy for energy efficiency in a library building. *MATEC Web of Conferences*. 2019;266:01004–01004. doi:10.1051/matecconf/201926601004.