International Journal of Architectural Engineering & Urban Planning, Volume 32, Number 1,2022
DOI: 10.22068/ijaup.32.1.623

Research Paper

Achieving Green Architecture Using BIM and Technology (VR -AR) in Tehran (Case study: Green villa building in Lavasan region of Tehran - Iran) †

Mohammad Behzadpour, Mehdi Khakzand *

Department of Architecture, School of Architecture and Environmental Design, Iran University of Science and Technology, Tehran, Iran

Received: January 2021, **Revised:** October 2021, **Accepted:** November 2021, **Publish Online:** November 2021

Abstract
Today, the use of building information modeling (BIM) has become widespread in developed countries; however, in Iran, the use of BIM-based software has received less attention for some reasons. In the present study, in the first phase, library studies and data collection related to research objectives have been surveyed. Then the identification of indigenous indices of green architecture in Iran was identified and explained through the Delphi method with Kendall's W correlation coefficient in SPSS software as a table Test Statistics. Finally, a green villa building in the Lavasan area in Tehran was detected and designated as a sample to be studied. The building was simulated using Virtual Reality (VR) and Augmented Reality (AR) technologies in order to better understand its environment. Moreover, the energy consumption of the mentioned building during the previous year was studied by modeling it in Revit software. The results of the research indicate that the selected building, which has been claimed to be green, has a distance of 58 kWh / m² with the global standards of ASHRAE and LEED. Accordingly, the studied building does not have the fundamental requirements and basic principles to receive the green building certification according to these international rating systems. Thus, with regard to the green building information modeling in Iran, it could be inferred that due to the lack of an indigenous guide (in terms of energy consumption) provided by the authorities, the environmental ecosystems as global assets are at risk.

Keywords: *Green architecture, Energy consumption, Environment, BIM, VR, AR.*

1. INTRODUCTION

In the contemporary world, preserving the environment and saving fossil fuels have become a crucial and prevalent approach at the international level. On the other hand, the increase in urban population along with issues such as energy shortages and global warming has caused many problems. These issues have turned into current predicaments that, despite our reluctance, we have to accept as the legacy of the present century. Accordingly, the use of construction methods with the least amount of harmful effects on the environment has become a worldwide solution. However, the current situation of Iran in terms of energy consumption and excessive carbon production, which has a high share in endangering the global environment, is disappointing and deplorable compared to other countries. To overcome this crisis and keep pace with the international community in protecting the environment, it will need to take steps in various areas, including the construction industry, which has a significant share in energy consumption.

† The present article is taken from postdoctoral studies of Dr. Mohammad Behzadpour, in the School of Architecture and Environmental Design, Iran University of Science and Technology.Mohammad Behzadpour: Department of Architecture, Hashtegerd Branch, Islamic azad University, Hashtgerd, Iran

* *Corresponding author: mkhakzand@iust.ac.ir*

Consequently, the major question of the research would be posed as follows: Is it possible to take effective steps to reduce the destructive effects of the construction industry on the environment and the global ecosystem by using local regulations and building information (BIM) modeling?

Considering the current situation in the country, the main issue of the research is the lack of guidelines and local standards for modeling the information of green buildings with regards to the annual energy consumption of buildings in Iran. In addition, one of the main objectives of the research is identifying and introducing green architectural factors in Iran in order to preserve the global ecosystem. Demonstrating the vitality and necessity of protecting the environment could have an essential impact on other third-world countries that have not yet taken action to develop their own indigenous regulations.

In the present study, by examining the studied building by modeling the information and analyzing the existing conditions, its compliance with international standards, the standards used for green buildings in Iran, and its compliance with international standards were studied.

Therefore, the results of the present study can be useful and practical not only for Iran but also for the global village to preserve the environment as a worldwide asset.

2. MATERIALS

2.1. Green (Sustainable) Architecture

Humans, in response to global warming, energy shortages, and the challenges of environmental degradation, have made attempts to promote low-carbon green buildings and cities with an approach to environmental health. In fact, as it is presented in Table 1, green building refers to the entire life cycle of the building, which includes maximum savings (energy resources, water, land and materials environmental protection, pollution reduction, and efficient use of space) for people and ultimately creating harmony between nature and human(Borrmann et al., 2015). Green architecture defines the understanding of environmentally friendly architecture in all categories and contains global satisfaction(Tascı, 2015). In the process of implementing green architecture, sustainable design methods can be applied to analyze the effects of green buildings. Today, the integration of green technology designs and structures would be more logical and efficient to be utilized for design and construction (Bernstein et al., 2010)

Sustainable design methods in BIM are commonly used in order to analyze the effects of green buildings, including all aspects of lighting, energy efficiency, material stability, and other building functions (Krygiel & Nies, 2008). The methods used in cost-benefit studies of green buildings can be categorized in different ways based on data collection and analytical approaches. Each method has its advantages and disadvantages with divergent capabilities (Khoshbakht et al., 2017).

2.2. Building Information Modelling (BIM)

Traditional design methods, which were often performed without energy evaluation in the past, have lost their credibility in today's world. An economy based on green architecture, sustainable development goals, and Building Information Modeling (BIM) can be used in a single building in a city as a separate unit according to its life cycle (Zhou et al., 2020). In addition to building information modeling, there should be lean design management, according to which the contractor can request subtle details to increase mutual understanding between project stakeholders from the very beginning of the project (Uusitalo et al., 2019).

Today, building information modeling (BIM) has become a constant model for the development of advanced methods in project delivery. Projects performed in this way provide a collection of highly sensitive building data in terms of geometry and position. They withhold unique identification capability as well as plenty of descriptive and executable metadata available (Gubbi et al., 2013). This powerful tool has taken almost two decades to reach its current state (Borrmann et al., 2015), and the activities performed within it include the production and processing of digital profiles to describe spaces and functions. The result of building information modeling helps those involved from the first stages of idea generation in design to construction and finally operation throughout the project (Golabchi et al., 2016). There are also some significant published results concerning BIM that are presented inTable 2:

In addition to this, various software are used in the world as Building Model Information (BIM). In the United Kingdom, since 2013, the use of Revit software has the highest user rate with 49%

(BIMtalk, 2013), and in the United States, according to a study conducted in 2012, the use of software under Autodesk for example Revit, Bently, ArchiCAD, MagiCAD, DigitalProject, and TeklaStructure has taken over the highest rate with 27% (Becerik-Gerber & Rice, 2010). As a result, it can be inferred that when it comes to Building Information Modeling, Revit software shines because it has attracted more users. Figure 1 shows the evolution of BIM use in other countries.

Table 1. Principles of Sustainable Architecture (Source: Authors)

	Human Comfort		Maintain the Life Cycle	Save Resources
1	Holistic approach	Respecting the users	Understanding the environment	Energy conservation
2	Quality-oriented	Understing people	Relationship with nature	Reduce consumptionof non-renewable energy sources
3	Looking to the future	Developing a participatory process in design	Understanding environmental effects	Ecological harmony

Table 2. Summary of Research Background Concerning BIM (Source: Authors)

No.	Title	Year	Author(s)	Results
1	Green BIM	2008	Eddy Krygieland Brad Nies	Sustainable design approach in projects (Krygiel & Nies, 2008)
2	BIM and Integrated Design	2011	Randy Deutsch	BIM is a common chapter of art, knowledge, and technology (Deutsch, 2011)
3	BIM Handbook	2011	Chuck Eastman et al.	Introduction of BIM limits and definition of building information modeling guidelines (Eastman et al., 2011)
4	BIM and Construction Management	2015	Brad Hardin and Dave McCool	Workflow using building information modeling (Hardin & McCool, 2015)
5	Best Practice BIM	2015	Dominik Holzer	Management dimension of building information modeling method (Holzer, 2015)
6	Validations for ensuring the interoperability of data exchange of a building information model	2017	Brad Hardin and Dave McCool	BIM is effective in reducing construction change (Khoshbakht et al., 2017)
7	Building Information Modeling in the Architecture-engineering Construction	2018	Zubair Ahmad Muhammad Jamaluddin Ahsen Magsoom	Building Information Modeling (BIM) is a promising technology for the construction sector (Ahmad et al., 2018)

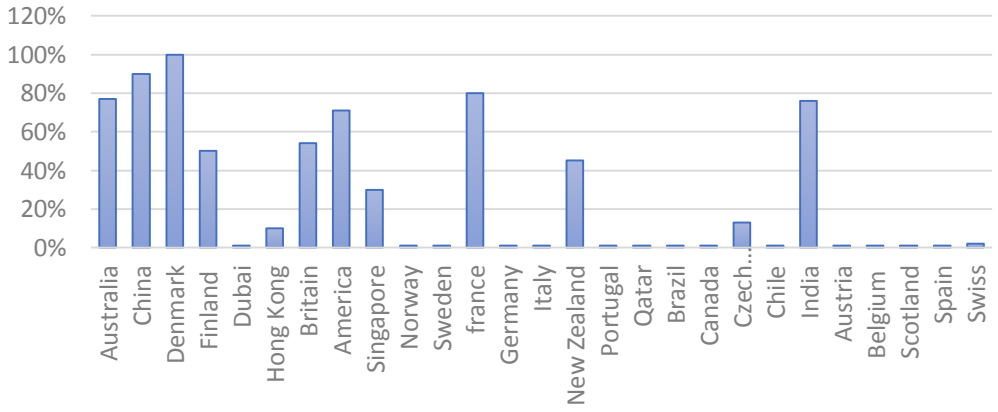


Fig 1. Evaluation of the Evolution of BIM Use in Other Countries (Source: Authors)

According to the chart above, China is one of the leading countries in applying Building Information Modeling, while it has localized standards as well. In China, manufacturing quality standards can be divided into four types of national, local, industrial, and corporate standards. Of these, national standards are the most valid and are the basis for the other three types of measures (Ma et al., 2018).

Another benefit existing in building information modeling is the availability of VR (for the ability of the audience to understand the project before construction and eliminate possible problems that will lead to savings in construction costs and materials used) and AR technology (one of the features of the AR application in BIM is the maintenance of the building after execution, through which it will be possible to obtain accurate information about the location and where the pipes of mechanical and electrical installations of the building). By building modeling, it is possible to use immersion in both virtual and augmented reality along with Building Information Modeling (BIM) technology, which could increase the usual process of planning a physical activity space. Moreover, the level of productivity in the industry can also be improved and expanded by using the knowledge of experienced workers and combining it with construction (Getuli et al., 2020). Stakeholder participation, support design, design review, construction support, operations, management support, and training are all the advantages of virtual reality and augmented reality that building information modeling (BIM) provides users (Delgado et al., 2020). With VR and AR in the construction industry, in addition to the three-dimensional perception of visual aspects before construction and during operation of the building, the safety of workers could also be ensured at work (Li et al., 2018). Table 3 compares the average percentage of use of different software based on BIM in the UK and America.

3. RESEARCH METHOD

In the present study, after library studies and the literature review, the Delphi method (a structured method that has a framework for group communication between experts and experts so that they can use it to make decisions and analysis in conditions of ambiguity with the least possible error) was used to identify the ingenious green architecture features of Iran. Then, by modeling the building information studied in Revit software, through the Insight plug-in (for modeling building information according to Figures 7 to 13 and in terms of energy consumption according to Tables 6 to 8), the energy consumption of a green villa in the Lavasan region of Tehran, Iran, was analyzed and compared with the global standards of ASHRAE. Finally, the building was simulated using VR and AR technology so that the user could better understand the simulated environment.

3.1. Introduction of the Case Study

In order to achieve the research objectives, investigating the effect of green Building Information Modeling (BIM) on reducing energy consumption, a villa building (in Lavasan region, 11 km northeast of Tehran, Iran) which is considered as a green building based on the principles and characteristics of construction was detected. This villa has an area of 320 square meters, and it was chosen and modeled in Revit software by the researchers of this study. The purpose of selecting this green villa is to check its status according to the ASHRAE standard in Revit software. Figure 2 illustrates the exterior view of the villa understudy, the area of Lavasan, and the map of the site. Figure 3 shows the villa's location on the map, ground floor plan, first and north side architectural view, south side structure view, east side mechanical installation view, and view of the villa's modeling in Revit software.

Table 3. Average Percentage of Use of Each Softwar based on BIM in the UK (BIMtalk, 2013) and America (Becerik-Gerber & Rice, 2010)

No.	Software	Country		Usage	No	Software	Country		Usage
		UK	US				UK	US	
1	Revit	*	-	49%	10	Graphisoft	--	*	14%
2	IFC	*	-	13%	11	Bently	-	*	6%
3	Bently	*	-	10%	12	Navisworks	-	*	9%
4	Archi Cad	*	-	18%	13	Vectorworks	-	*	4%
5	Vectorworks	*	-	10%	14	Sefaria	--	*	2%
6	Autodesk	-	*	27%	15	Share Point	-	*	6%
7	Box	-	*	2%	16	Solibri	-	*	3%
8	Buzzsaw	-	*	12%	17	Tekla	-	*	8%
9	Dropbox	-	*	4%	18	Aconex	-	*	3%

3.2.1. Sunlight

Sunlight is needed to create natural light in the building. However, since this light is eventually converted into heat, the amount of radiation required for each building must be determined by its location's type and climatic conditions. Figure 5 illustrates the sun ray positions and angles according to the latitude of 35 degrees north, where Tehran is located. Figure 4 shows the sun's movement in a building located in the northern hemisphere facing south.

According to Figure 4, in summer, the sun rises from the northeast of the building and sets in the northwest, and in winter, the sun rises from the southeast and sets in the southwest of the building. Only on March 21 and September 23, the sun rises completely from the east and sets in the west (Hossein Abdi et el., 2012). The position and angles of the sun rays are among the factors that will affect the orientation of the building based on climate.

Fig 2. Image of the Exterior of the Villa in Question and the Condition of its Area (Source: Maps)

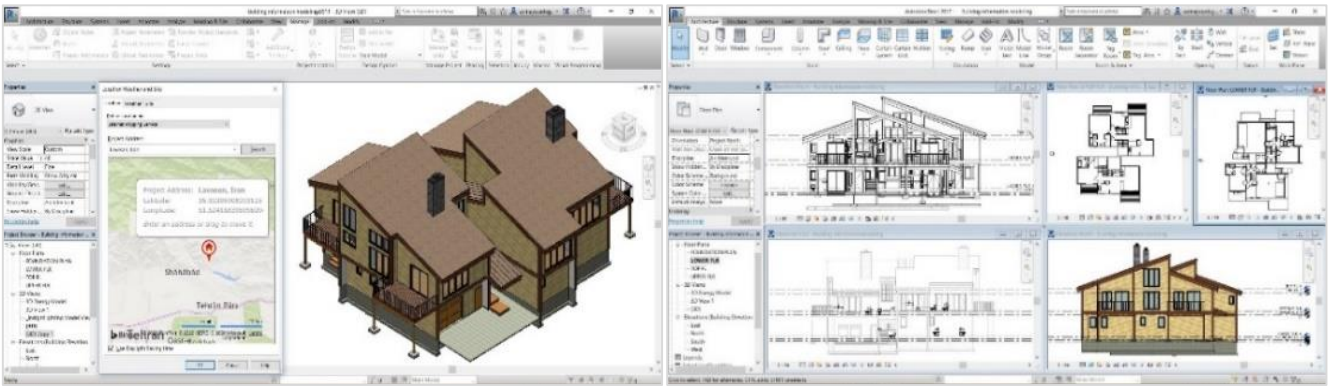


Fig 3. Plans, Views, and Location of the Modeled Villa in Revit Software (Source: Authors)

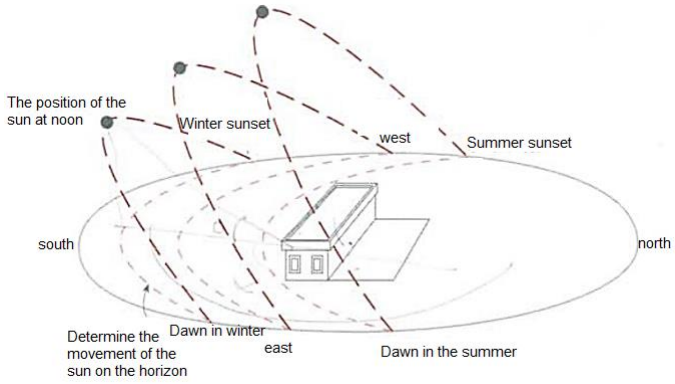


Fig 4. The Position of the Sun Relative to the Earth Relative to a Building Located in the Northern and Southern Hemispheres (Hossein Abadi et al., 2019)

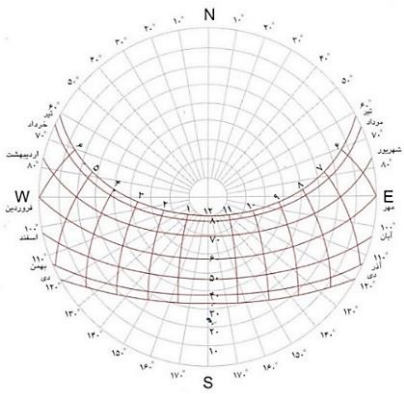


Fig 5. position and Angles of Solar Radiation according to Latitude 35 Degrees North (Hossein Abadi et al., 2019)

3.2.2. Wind Direction and Speed

Creating natural ventilation in the building depends on the pressure difference that the wind makes in its outer walls (Hossein Abadi et al., 2019) (p. 62). Figure 6 illustrates the direction and speed of wind in different seasons of the year and the annual length in Tehran. Provided that the diagram, the building's position, and the sun angles are utilized as a criterion for selecting the building's orientation, they can minimize energy consumption and create a positive relationship between the structure and the environment.

Building energy modeling is usually used in various ways to design buildings with energy efficiency, including simple, computational, static, advanced, and dynamic (Schlueter & Geyer, 2018). Therefore, in the present study, the Revit software building information model was done based on quantitative analyses to check the amount of energy consumption.

3.3. Identification and Introduction of Indigenous Green Architecture Features (Lavasan, Tehran, Iran)

According to Table 4, the results are based on the weighting of Iranian indigenous green architecture indicators obtained from the Delphi method and using the Kendall correlation coefficient (the correlation coefficient between two variables means the ability to predict the value of one in terms of the other). In this coefficient, instead of the value, the order of values is used to measure the degree of dependence. With this index, the degree of consistency of the ranks is measured in SPSS software. It should be noted that the use of the Kendall correlation coefficient in the present study is due to the nature of data rankings.

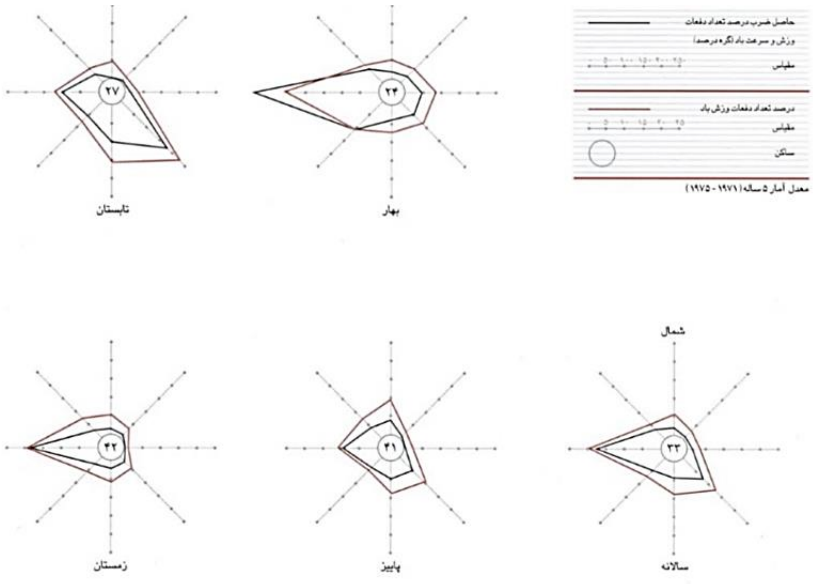


Fig 6. Direction and Speed of Wind in Tehran (Schlueter & Geyer, 2018)

Table 4. The Results Obtained from the Weighting of Green Architectural Indicators by Delphi Method and Kendall Correlation Coefficient in SPSS Software (Source: Authors)

Test Statistics		Ranks	
N	10		Mean Rank
Kendall's Wa	.542	Energy conservation	4.10
Chi-Square	27.117	Working with climate	4.35
df	5	Minimizing the use of new sources	1.55
Asymp. Sig.	.000	Respecting the users	3.20
a. Kendall's Coefficient of Concordance		Respecting the site	3.80
		Holistic approach	4.00

According to the above table, the Kendall correlation coefficient was used in SPSS software to complete the Delphi technique rounds. To determine the validity of experts' views, we can refer to Kendall's Wa, which indicates coordination of 0.54 between views in the Test Statistics table. A significant value (.000) is also calculated, which means that the observed coordination coefficient is significant. According to the formula for calculating the Kendall correlation coefficient, in which n samples are examined, the following relation is established:

$$T = \frac{2S}{n(n-1)}$$

The value of S is the sum of the difference between ui (the number of data after the desired data and are more than that) and vi (the number of data after the desired data and are less than that).

$$S = \sum_{i=1}^{n} d_i = \sum_{i=1}^{n} (u_i - v_i)$$

According to the above table, the correlation coefficient test between the two indicators of energy conservation and work with climate was performed in SPSS software based on the data in Table 4. As can be seen, the value of the correlation coefficient based on experts' view is 0.67, which shows the significance of the coefficient under study based on the Delphi method. Therefore, it can be concluded that in order to design and implement a building with a green architectural approach, the climate and its other components such as solar energy, direction, and wind speed have the highest impact. The next critical one is energy conservation with the components of reducing the use of fossil fuels and renewable energy.

4. ANALYSIS OF THE FINDINGS

According to the results, it seems essential to address wind and solar energy issues before presenting the results of investigation and analysis of building energy due to the effect of the mentioned components on the amount of energy consumption in the building. Table 6 shows the wind direction and speed in the building in all seasons and annually (reviewed and modeled in Revit software; by Insight plug-in and according to the output taken from Green Building Studio site).

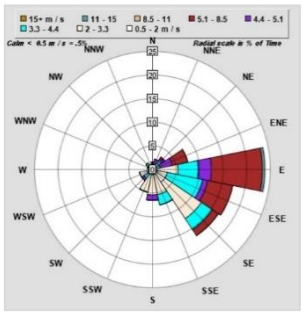
Figure 7 shows the study results of solar energy effect on the roof of the building in the Lavasan area of Tehran, from October 22 to November 20, 2020. As is illustrated in the diagram, the maximum amount of solar energy received from the roof of the building is 59 kWh per square meter on the west side.

Another possibility that Revit software provides is the analysis of solar energy. Figure 8 demonstrates the analysis of solar energy inside the bedroom in the middle of the day on November 20, 2020.

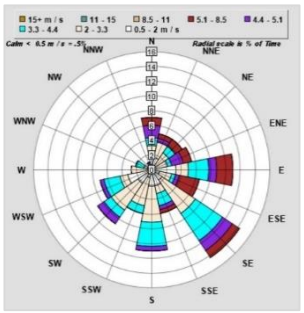
Table 5. Correlation Coefficient Test between Energy Conservation and Work with Climate in Green Architecture (Source: Authors)

NO	Correlations				
				Energy conservation	Working with climate
1	Kendall's tau_b	Energy conservation	Correlation Coefficient	1.000	.667*
2			Sig. (2-tailed)	.	.046
3			N	10	10
4		Working with climate	Correlation Coefficient	.667*	1.000
5			Sig. (2-tailed)	.046	.
6			N	10	10
Total	*. Correlation is significant at the 0.05 level (2-tailed).				

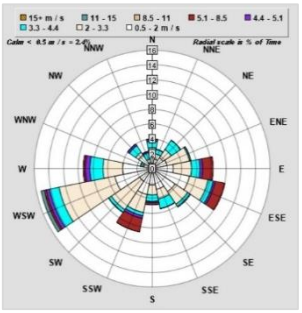
Table 6. Check the Wind Situation in all Months of the Year and Annually (Source: Authors)



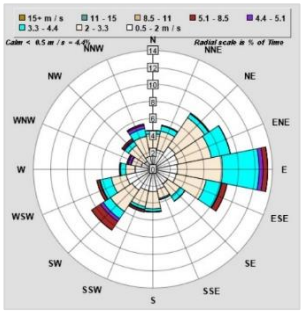
Summer, Wind condition at 13:00



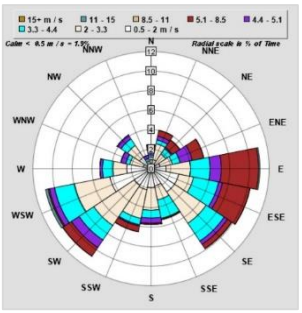
Spring, Wind condition at 13:00



Winter, Wind condition at 13:00



Autumn, Wind condition at 13:00



Annual situation analysis in Lavasan region of Tehran

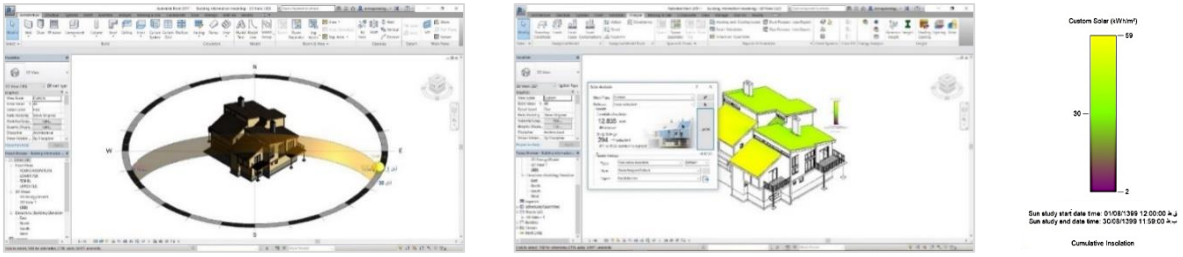


Fig 7. Investigation of the Effect of Solar Energy on the Roof (Source: Authors)

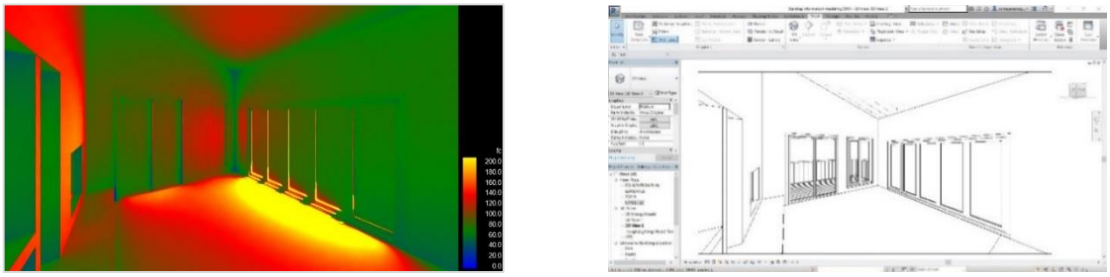


Fig 8. Analysis of Solar Energy in the Interior of the Main Bedroom (Source: Authors)

In Figure 9, the diagrams show an investigation of fuel consumption per cubic meter, the amount of electricity consumption per kilowatt-hour, and the average energy consumption in the building during a year.

The diagrams above and their results indicate that the highest energy consumption in the simulated building is 47% for heating the building, and the lowest is 4% for hot water. Nonetheless, space coolers also have a significant impact on increasing energy consumption in the building accounting for 25% of the total energy consumption in the building. Based on the results, the highest amount of energy consumption in the building is spent on heating and cooling the space, which imposes extra expenditures on the building's residents. Figure 10 illustrates the cost based on energy consumption, and Table 7 shows the comparison of energy consumption and cost. It should be noted that cost estimates are based on US dollars.

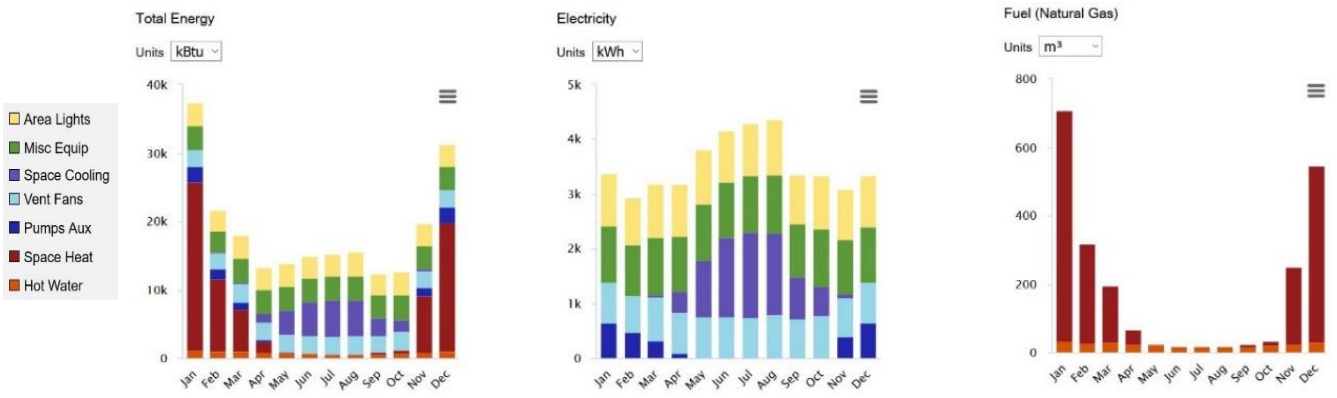


Fig 9. Assessing the amount of energy consumption during a year, Source: authors

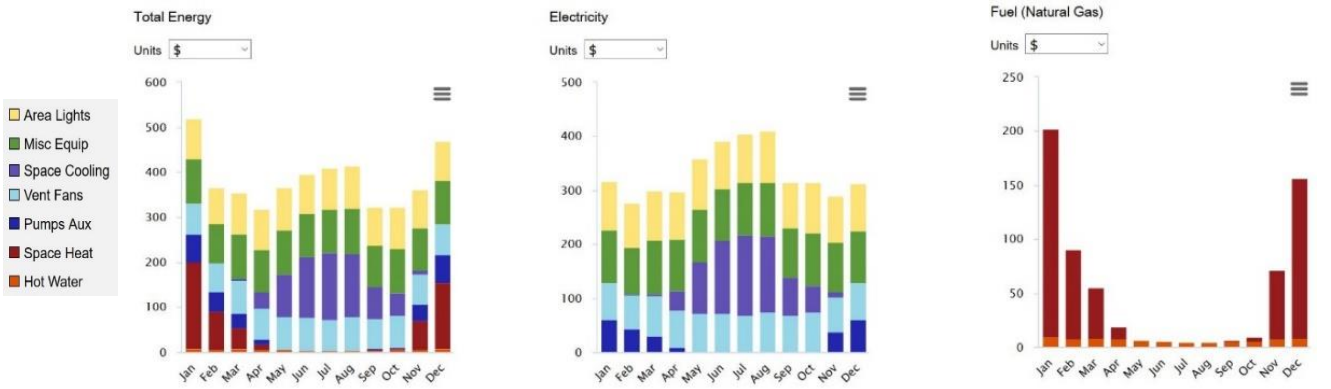


Fig 10. Review of Energy Consumption Costs during the Year **(**Source: Authors)

Table 7. Comparison of Average Energy Consumption and Cost in all Months of the Year according to the Modeling done by the Authors (Source: authors)

Consumption period (month)	Light		Other equipment		Coolers		Ventilators		Pumps		Heaters		Hot water	
	Energy	Cost	Energy	Cost	Energy	Cost	Energy	Cost	Energy	Cost	Energy	Cost	Energy	Cost
January	9 %	90	9 %	97	0	0	7 %	69	6 %	61	66 %	193	3%	9
February	14 %	81	15 %	87	0	0	11 %	64	7 %	44	49 %	83	5 %	8
March	19 %	92	20 %	98	1 %	4	15%	75	6 %	31	34 %	47	6 %	8
April	24 %	89	26 %	95	10 %	36	19 %	69	3 %	10	11 %	12	7 %	7
May	24 %	92	26 %	98	25 %	96	19 %	72	0	0	0	0	6%	5
June	22 %	89	23 %	95	33 %	136	18%	72	0	0	0	0	5 %	5
July	21 %	90	23 %	97	35 %	148	16 %	69	0	0	0	0	4 %	5
August	22 %	95	23 %	100	33 %	140	18 %	75	0	0	0	0	4 %	5
September	25 %	83	27 %	92	21 %	71	20 %	66	0	0	2%	2	6 %	5
October	27 %	92	28 %	98	14 %	49	21 %	72	1 %	2	3 %	2	6 %	6
November	16 %	86	17 %	93	2 %	8	12 %	67	7 %	37	42 %	64	5 %	7
December	10 %	87	11 %	95	0	0	8 %	69	7 %	61	60 %	148	3 %	9

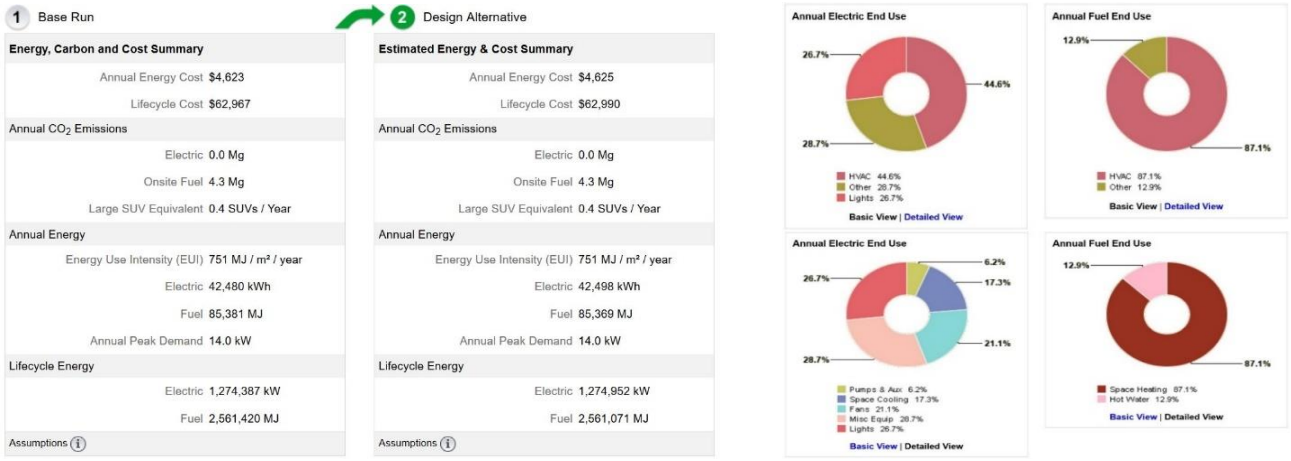


Fig 11. The Amount of Carbon Production according to the ASHRAE Standard during One Year in the Villa under Study (Source: Authors)

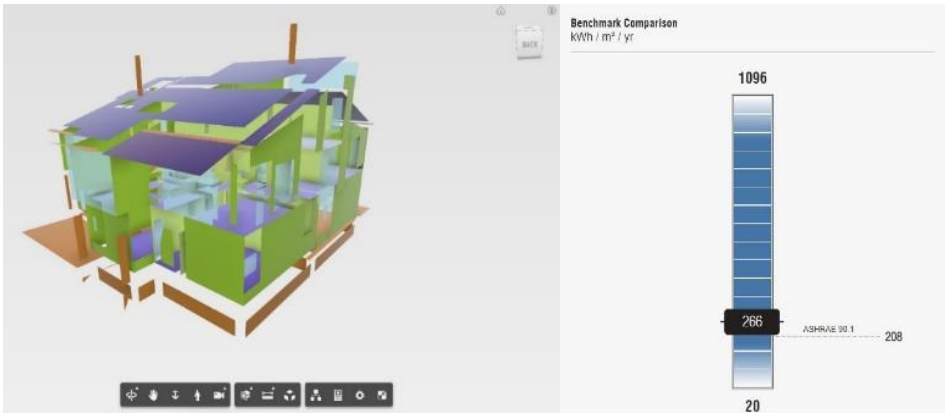


Fig 12. Status of the modeled building on the Insight360 site and ASHRAE standard rating (Source: authors)

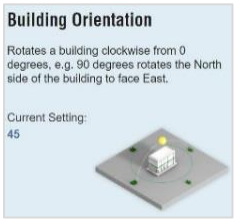
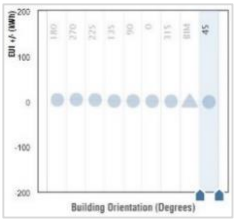
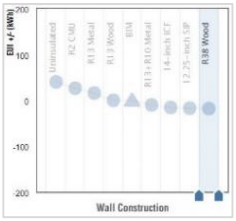
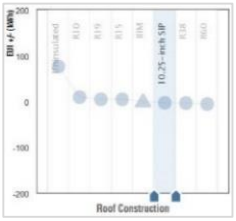
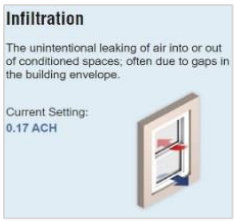
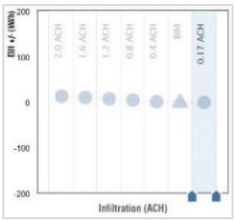
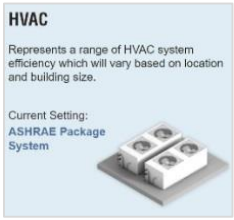
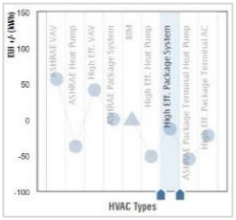
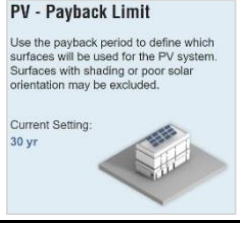
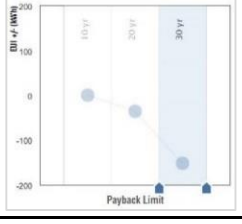
In Figure 11, the results of a study of carbon production are illustrated during the year in Lavasan's green villa under study according to the ASHRAE standards.

As can be seen in the diagram above, the acceptable rating for receiving this standard is 208 kWh per square meter during a year, but the rating received by the villa in the present study is 266 kWh/M2. The diagram above shows that the green villa building in Lavasan, Tehran, has disadvantages in energy consumption in the field of cooling, heating, and ventilation; therefore, it cannot receive the standard. It should be noted that the results in the energy consumption charts have already indicated that the energy consumption for cooling and heating the building is higher than other energies, which means that it will produce more CO2 or carbon. In other words, according to the factors studied in the building, it will never succeed in receiving the ASHRAE global standard.

Nevertheless, it may be possible to reduce the heating and cooling energy consumption and receive the ASHRAE standard with the help of the suggested solutions in the Insight plug-in in Revit software and by applying several changes in the modeling. The solutions proposed by Insight360 remarkably offer solutions that point to the building's pre-construction modeling. The Insight 360 plugin is a powerful add-on for calculating the thermal and refrigeration load of a building, the effect of sunlight on the exterior surfaces of the building, analyzing the brightness of the space in general and in part, and the energy consumption costs of the building. This confirms the importance of pre-construction considerations, such as the rotation angle of the building, which by selecting a 45-degree angle, would decrease 3 kWh/m2/yr and could bring the building rank to 263 according to the standard. Another solution suggested by Insight360 is to change the material in the modeled building. By choosing a wooden structure, the building's energy consumption would be reduced to 243 kWh per square meter, and by changing the angle of the roof inclination, the modeled building could rank 229. The degree of penetration and communication of the inside and outside space is another influential factor in reducing the consumption of cooling and heating energies. Should this development take place, the obtained rank would

reach 223. If standard equipment were used for heating and cooling the building, and meanwhile, the proposed changes in the rotation angle of the building, type of structure, roof slope angle, and penetration rate occurred, the building would rank 218 according to the ASHRAE standard. It should be noted that the proposed solutions affect each other by being decreased or increased. By implementing the suggestions provided by Insight360, the rank of the building could change. Another suggested solution in the mentioned plug-in is to use renewable energy in 10, 20, or 30-year intervals by selecting a 30-year period, the energy consumption of the building reaches 204 kWh/m2/yr. Thus, the mentioned building can receive the ASHRAE standard by applying the above changes. Table 8 shows the implementation of the solutions proposed by Insight360 and its results.

Table 8. Implementation of the Proposed Solutions by Insight360 and its Results (Source: Authors)

No.	Proposed Suggestion	Applying Changes	Result	Description
1				Rotating the building 45 degrees, the energy consumption reaches 263 kWh/m2.
2				Changing the structure of the building to wooden structures, the amount of energy consumption reaches 243 kWh/m2.
3				Changing the slope of the roof, energy consumption reaches 229 kWh/m2.
4				Reducing the amount of penetration and controlling the relationship between indoor and outdoor space, energy consumption reaches 223 kWh/m2.
5				Changing the mechanical equipment, energy consumption reaches 218 kWh/m2.
6				Using renewable energy in a period of 30 years, the amount of energy consumption reaches 204 kWh/m2.

In case the changes proposed by the Insight360 and shown in Table 6 are made, the annual rating of building energy consumption could reach 204 kWh/m2/yr, as illustrated in Figure 13. Considering that the acceptable rating for receiving the ASHRAE standard is 208, it must be said that the modeling done in Revit software could receive the ASHRAE standard. While this is, at present, the current green villa in the Lavasan area of Tehran that is far from obtaining a high standard because its ranking in energy consumption, as previously announced, scores at 266 kWh/m2/yr. According to the researchers of the present study, this building could receive the ASHRAE global standard provided that, before construction, all the design and simulation steps were done in Revit software, and then energy analysis was obtained by Green Building Studio, and the proposed Insight360 solutions were applied to reduce annual energy consumption, and finally if all the changes were made in the rotation angle of the building, structure, roof slope, penetration rate, cooling and heating equipment, use of renewable energy, etc.

In sum, it can be said that Building Information Modeling (BIM) not only offers the benefits of annual energy consumption and provides information and facilities available before building a project but also it provides users with other benefits such as virtual reality (VR) by which the client can acquire a sufficient understanding of the environment before implementing a project with VeeR software. AR technology is another advantage of building information simulation that presents particular features to users. One of the features of the AR application in BIM is the maintenance of the building after execution, through which it will be possible to obtain accurate information about the location and where the pipes of mechanical and electrical installations of the building, without destruction and with minimal damage to the building. Figures 14 and 15 show VR-AR of troubleshooting and the exterior and interior space of the simulated project.

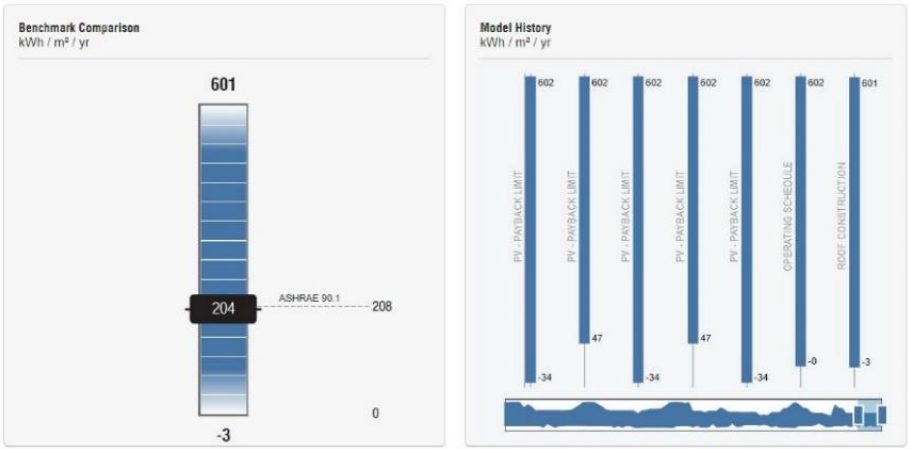


Fig 13. The Result of Applying the Proposed Solutions (Insight360) and Achieving the ASHRAE Standard (Source: Authors)

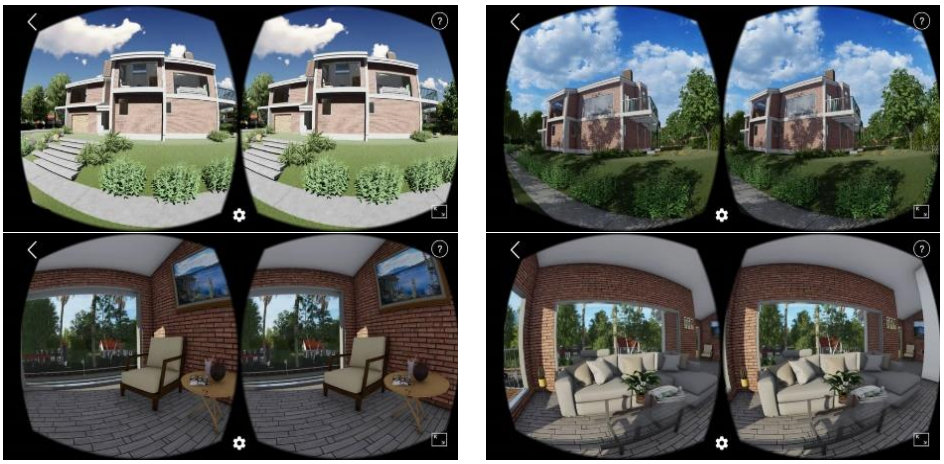


Fig 14. Virtual Reality (Vr) of the External and Internal Space of the Project Modeled in Revit Software (Source: Authors)

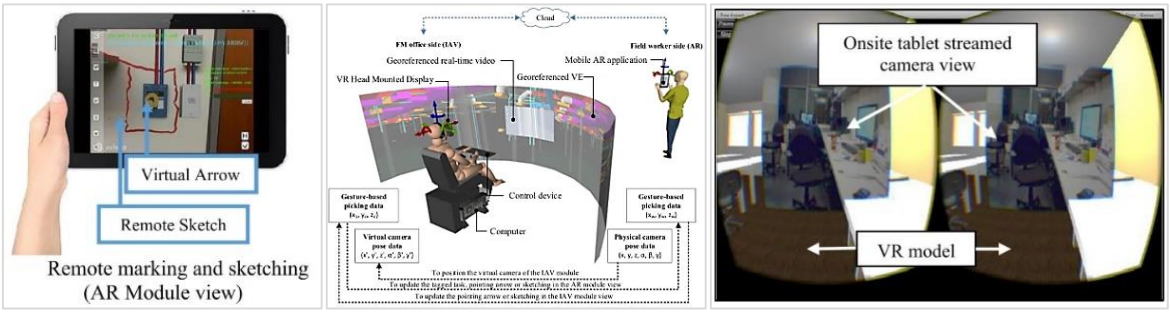


Fig 15. The Difference between AR and VR and Visual Interaction with a Virtual Environment (El Ammari & Hammad, 2019)

5. CONCLUSION

The ever-increasing expansion of cities and population growth has led to the overuse of energy, which in turn increases the level of damage to the environment. Furthermore, it makes countries face energy shortages and threaten human life. According to the study's mentioned issues and objectives, one of the important results of this study is to identify the indigenous features of green architecture in the Lavasan region of Tehran, Iran, which was explained by the Delphi method with Kendall's Wa correlation coefficient as a Test Statistics table. These factors can be used as a way to design indigenous green architecture to preserve the global ecosystem. On the other hand, studies show that due to the lack of use of BIM in the Iranian construction industry, the existing buildings have irreversible effects on the environment with excessive energy consumption. Hence, to prevent such damages, guidelines and local standards must be developed. Consequently, the next step needs to be proper requiring and monitoring the implementation of the approved regulations in all construction stages. As a result, it is worth reminding that considering the above solutions, green buildings could be constructed that cause less damage to the environment by producing oxygen and reducing carbon (CO2) and eventually taking a practical step towards preserving the ecosystem as a universal asset.

In conclusion, the spread of awareness about sustainable construction and the prevalence of environmental concerns have led to the development of a new field in project management called "Green Project Management" (GPM), which is suggested to be employed in the design and implementation of green buildings in all countries. Green Project Management (GPM), as a global organization that seeks to adapt projects to the environment through sustainable project management methodologies and standards in the hope of promoting sustainability and regeneration of our planet. One of these methodologies is PRISM, which with a project management approach and a focus on sustainable development, allows companies to integrate sustainability in the work process, manage their projects, and thus reduce the negative environmental impacts.

REFRENCES

Ahmad, Z., Thaheem, M. J., & Maqsoom, A. (2018). Building information modeling as a risk transformer: An evolutionary insight into the project uncertainty. *Automation in Construction*, *92*, 103-119.

Becerik-Gerber, B., & Rice, S. (2010). The perceived value of building information modeling in the US building industry. *Journal of Information Technology in Construction (ITcon)*, *15*(15), 185-201.

Bernstein, H., Jones, S., Russo, M., & BIM, G. (2010). How Building Information Modeling is Contributing to Green Design and Construction, Smart Market Report. In: McGraw-Hill Construction, Bedford.

BIMtalk. Software_Applications - BIMTalk. NBS' National BIM Library, Available at: http://BIMtalk.co.uk/software_applications [Accessed November 26, 2015].

Borrmann, A., König, M., Koch, C., & Beetz, J. (2015). *Building Information Modeling: Technologische Grundlagen und industrielle Praxis*. Springer-Verlag.

Delgado, J. M. D., Oyedele, L., Demian, P., & Beach, T. (2020). A research agenda for augmented and virtual reality in architecture, engineering and construction. *Advanced Engineering Informatics*, *45*, 101122.

Deutsch, R. (2011). *BIM and integrated design: strategies for architectural practice*. John Wiley & Sons.

Eastman, C. M., Eastman, C., Teicholz, P., Sacks, R., & Liston, K. (2011). *BIM handbook: A guide to building information modeling for owners, managers, designers, engineers and contractors*. John Wiley & Sons.

El Ammari, K., & Hammad, A. (2019). Remote interactive collaboration in facilities management using BIM-based mixed reality. *Automation in Construction*, *107*, 102940.

Getuli, V., Capone, P., Bruttini, A., & Isaac, S. (2020). BIM-based immersive Virtual Reality for construction workspace planning: A safety-oriented approach. *Automation in Construction*, *114*, 103160.

Golabchi, M; Golabchi, A; Noorzaei, E; Qarooni, K. Tehran, 2016.

Gubbi, J., Buyya, R., Marusic, S., & Palaniswami, M. (2013). Internet of Things (IoT): A vision, architectural elements, and future directions. *Future Generation Computer Systems*, *29*(7), 1645-1660. https://doi.org/https://doi.org/10.1016/j.future.2013.01.010

Hardin, B., & McCool, D. (2015). *BIM and construction management: proven tools, methods, and workflows*. John Wiley & Sons.

Holzer, D. (2015). *The BIM Manager's Handbook, Part 1: Best Practice BIM*. John Wiley & Sons.

HosseinAbadi, S., Lashkari, H., & Moqadam, M. (2019). Climatic Design of Residential Building of Sabzevar with Emphasis on Building Orientation and Depth of Canopy.

Khoshbakht, M., Gou, Z., & Dupre, K. (2017). Cost-benefit Prediction of Green Buildings: SWOT Analysis of Research Methods and Recent Applications. *Procedia Engineering*, *180*, 167-178. https://doi.org/https://doi.org/10.1016/j.proeng.2017.04.176

Krygiel, E., & Nies, B. (2008). *Green BIM: successful sustainable design with building information modeling*. John Wiley & Sons.

Ma, Z., Cai, S., Mao, N., Yang, Q., Feng, J., & Wang, P. (2018). Construction quality management based on a collaborative system using BIM and indoor positioning. *Automation in Construction*, *92*, 35-45.

Schlueter, A., & Geyer, P. (2018). Linking BIM and Design of Experiments to balance architectural and technical design factors for energy performance. *Automation in Construction*, *86*, 33-43.

Tascı, B. G. (2015). "Sustainability" Education by Sustainable School Design. *Procedia - Social and Behavioral Sciences*, *186*, 868-873. https://doi.org/https://doi.org/10.1016/j.sbspro.2015.04.199

Uusitalo, P., Seppänen, O., Lappalainen, E., Peltokorpi, A., & Olivieri, H. (2019). Applying Level of Detail in a BIM-Based Project: An Overall Process for Lean Design Management. *Buildings*, *9*(5). https://doi.org/10.3390/buildings9050109

Zhou, J.-G., Li, L.-L., Tseng, M.-L., & Lin, G.-Q. (2020). Green system reliability assessment method based on life cycle: Resources and economical view. *Journal of Cleaner Production*, *251*, 119786. https://doi.org/https://doi.org/10.1016/j.jclepro.2019.119786.

AUTHOR (S) BIOSKETCHES

M. Behzadpour., *Department of Architecture, School of Architecture and Environmental Design, Iran University of Science and Technology, Tehran, Iran*
Email:*mohammad_behzadpour@mail.iust.ac.ir*

M. Khakzand., *Department of Architecture, School of Architecture and Environmental Design, Iran University of Science and Technology, Tehran, Iran*
Email:*mkhakzand@iust.ac.ir*

COPYRIGHTS

HOW TO CITE THIS ARTICLE

Behzadpour, M., Khakzand, M. (2022). Achieving Green Architecture Using BIM and Technology (VR -AR) in Tehran. (Case study: Green villa building in Lavasan region of Tehran - Iran). *Int. J. Architect. Eng. Urban Plan*, 32(1): 1-14, https://doi.org/10.22068/32.1.623.

URL: http://ijaup.iust.ac.ir