Logistics, supply chain, sustainability and global challenges
Vol. 13, Iss. 1, December 2022, 50-60
doi: 10.2478/jlst-2023-0004

Analyzing the energy analysis tool (The Autodesk Insight 360) of BIM during the early stages of the design process in terms of window factors in a single-family house

Fatemeh BOLOORCHI[1]

[1]University of science and technology of Tehran in Iran, architecture department

***Abstract* - In designing eco-buildings, windows play a big part in minimizing the energy load. There has not been any easy-to-use software to speed up the process, even after many recent studies about environment-friendly window size, shading, position, and material. Thus, a single-family house with simple geometry in Kvemelto karti, Georgia, was simulated to introduce an alternative method to manage this gap. A building information model (BIM) was devised for this procedure through Autodesk Revit® due to its simplicity, popularity, interoperability and convenience among its users. Not to mention, the energy analysis tool (The Autodesk Insight 360) in Revit (BEM) displays the total energy load while, in this case, focusing on window size, position, material, and shading executed by Autodesk Green Building Studio®. The early energy analysis (the optimum window-to-wall ratio (WWR), the windows' location in the wall, material, and shading) suggested by BEM does not give enough information to apply in the early stages of design and create a net-zero-energy building. The aim is to show the gap between data-driven from BEM and design strategies and to display the information required to be more detailed. For this purpose, after using Insight 360 (a web-based tool) for investigating window shades, material, and WWR, it has been concluded that there is a need for a more convenient way to automate the process in more depth. They could help to pick a viable widow shading, size, position, and material. Besides, choosing determined factors using just BEM is not practical because detailed characteristics of window factors as determining elements are not defined. This tool has its limitations.**

Inex terms - window size, window material, widow shadings, window position, BIM, The Autodesk Insight 360

I. INTRODUCTION

More than 10% of the energy demands in buildings are caused by windows, increasing the total energy consumption derived from recent studies showing the impact of window factors on energy demand to reduce energy waste (Bokel, 2007; Koohsari Fayaz & Kari, 2015; Al-Tamimi, Fadzil & Harun, 2011). Despite these efforts, a user-friendly tool such as an energy analysis tool in Revit (BEM) has not progressed and developed enough to show more detailed data (either with simple or with complex geometry) that could be useful in the early stages of design (Vladimir, 2001). Conceptual building energy tools enable the creation of new energy-saving technologies. It might improve the technical efficiency of data analysis to make it simpler to compare and comprehend the effects of various options available directly from Autodesk Revit Architecture (Maurya, Kumar, Bharadwaj, Rawat & Kumar, 2021). The Autodesk Green Building Studio service may aid in changing the way building energy analysis is used in the design process (Zhang et al., 2023). After introducing Insight360, the aim is to investigate WWR, window shades and window material in this program further and pointing out its missing data that needs more investigation.

A. BIM

Building information modeling (BIM), which offers a comprehensive 3D model with comprehensive data that can work with other software applications, encourages collaboration between different disciplines (Eastman, Teicholz, Sacks & Liston, 2011). BIM is a novel technology that improves data management, multidisciplinary cooperation, and integrated building design (Mayouf & Boyd, 2013). Building performance simulation directs design decisions because of its capacity to manage enormous amounts of data and offer quick responses during design. Providing a smooth transfer of information from the building information model (BIM) to the building energy model (BEM) is the goal of using Building energy simulation in a project. However, seamless integration between BIM and BEM is still an area of research and is not yet widely used in the industry. As a result, the manual BEM construction process—described by O'Donnell et al. (2013) as "subjective, labor-intensive, time-intensive, and error-prone"—often results in wasted efforts and dissatisfied modelers without appropriate software interoperability. Motivations for achieving interoperability between BIM and BEM include significant time and effort savings, error reduction, and the repeatability of simulation models compared to present practice (Hitchcock & Wong, 2011). The degree of transfer success would depend on the quality of the architectural geometries. Given that, the BIM to BEM transfer process requires error-tracking, debugging, human adjustment, and the user's degree of knowledge. Without software programs supporting a thorough transfer process and technical expertise, as well as the industry culture of specialized practitioners has hindered the development and implementation of automated data exchange between BIM and energy simulation tools (Hitchcock & Wong, 2011). Many BIM models are created by designers unfamiliar with the complexities of energy modeling, producing inconsistent and error-prone development (Wetter & Van Treeck, 2017). These models perform poorly in energy modeling programs because they are mostly designed for construction documentation, and contain architectural details irrelevant to an energy model without necessary details such as clean space boundaries, and matching edges. According to Smart Market Report, surveys among practitioners revealed that a lack of tools, tools that are too technical or lack the needed functions in existing programs impedes the adoption of BIM for green projects, and most users are 'frustrated' by the lack of a fully integrated approach (Bernstein, Jones & Russo, 2010). Automated BIM to BEM translation was an "expensive and somewhat unusual option" in 2001 (Bazjanac, 2009), and it still is today.

Green Building Studio created the gbXML format in 2000 to simplify the transfer of building information recorded in CAD-based BIM, enabling interoperability between diverse building design and engineering analysis software packages (GbXML Inc, 2018). It is classified into three sections that offer geometry and construction information: Shell Geometry, Space Boundary, and Surface. Each BEM software may import a single gbXML file differently since each application does not recreate the model using all three categories but rather a mix of information to gain the geometrical information (IESVE, 2017). Open BIM is a global approach to collaborative building design, implementation, and operation based on open standards and processes (buildingSMART International, 2016).

There is a need for interoperability between BIM and BEM; as a result, the focus of this paper is on Insight360's dynamic platform. For analyzing the windows factors of this program in more detail, initially, this tool was analyzed. Relatively, recent initiatives such as Simergy, released in 2012 by Digital Alchemy (Digital Alchemy, 2018), and BIM server platforms such as EDM model Server (Singh, Gu & Wang, 2011) are actively pursuing BIM to BEM workflow improvement. Among three well-known and program (Insight360, Open Studio, and Virtual Environment (VE), representing a publicly accessible tool, a commercial-grade package, and a web-based analysis tool with BIM integration), Insight360 has gained more popularity. This is because Open Studio (an open-source application, SketchUp Plug-in) often encounters software issues, many of which go unnoticed by the user and result in crashes; locating and debugging issues, as well as gbXML importing is tedious, complex, and time-consuming. Furthermore, Trimble's SketchUp has transitioned to a web-only interface (Trimble Inc, 2018), raising concerns about the long-term viability of Open Studio as an offline SketchUp plugin, as the program may no longer be actively maintained. Besides that, The Virtual Environment from Integrated Environmental Solutions as a unique whole-building performance (BIM platform) simulation tool uses the APACHESIM proprietary simulation engine and does not let users access the simulation input source file for possible scrutiny or manual change. Many inherent hidden default settings for simulation are inaccessible (Attia, 2011), model viewing capabilities are restricted (Azhar, Brown & Farooqui, 2009), and the model must be updated in a plan or isometric perspective rather than a complete 3-D view. Detail refinement in the latter stages necessitates program knowledge (The American Institute of Architects, 2012). The deficiencies in operating these two interoperable programs make designers and architects to turn to The Autodesk Insight 360 application to analyze the energy performance of buildings (Zhang et al., 2023). After introducing this program, the aim is to investigate WWR, window shades and window material in this program further.

B. The Autodesk Insight 360 application

The Autodesk Insight 360 application, which debuted in November 2015, is a relatively new energy analysis tool. It evolved from Autodesk's Green Building Studio and was designed to merge BIM and BEM into the same software platform, in this case, Form It or Revit, to make the transition between the two models simpler. Insight 360 translates BIM models to BEM models automatically and simulates the BEM using Energy Plus and DOE2. DOE2 data is used to create a programmable online viewing interface. The Energy Plus file may be downloaded. For the time being, it is intended for preliminary energy analysis rather than extensive energy modeling due to the rough analysis resolution being pre-set at the total building level rather than each thermal zone, non-customizable operation schedule and HVAC systems, and so on. It serves as a marketing tool for designers, allowing them to simply and visually illustrate the wide energy consequences of their clients' actions

(Butts, 2016). Those with access to Insight's internet portal can examine high-level energy data without requiring the model or the Autodesk application. It is simple to keep track of model history and the effects of high-level energy parameter changes. Photovoltaics, orientation, window shading, general construction types, infiltration, lighting efficiency, daylighting and occupancy controls, general HVAC (heating, ventilation, and air conditioning), operating schedules, and plug loads are all examples of energy parameters. However, in this study, only windows factors are analysed. When the energy parameters are changed, the EUI (energy use intensity) automatically updates a dynamic color-coded building benchmark that depicts the performance levels of ASHRAE Standard 90.1 and Architecture 2030. The average energy cost is also updated automatically. Revit allows you to examine summary reports as well as analytical areas and surfaces per room. As XML files, construction values can be exported and changed (Butts, 2016).

However, With the probable exception of lighting reports, the application, despite claiming to have the accuracy of VE, Trace, or SEFAIRA, does not give enough detail to help in the paperwork required for sustainability programs such as LEED. As a result, if the energy model is to be utilized for compliance, another energy modeling tool must be employed (Butts, 2016). When you develop a BEM using Insight 360, a distinct 3D view of the BEM is produced in the same Revit file. Even though both the BIM and the BEM are in the same file, changes to the BIM do not instantly update into the BEM. A new BEM must be created, which will overwrite the prior one. Workflow is therefore unidirectional, with the web interface serving as a viewing window for pre-run energy studies rather than allowing modifications to the model itself. Insight360 will be impossible to execute energy simulations if the BIM model is inadequate or contains geometrical flaws, while a graphical BEM representation may be provided. If no simulation is done, no Energy Plus file is created. A separate login into Green Building Studio, rather than the Insight 360 online site, is necessary to download the input data file (Zhang et al., 2023).

Insight 360 works directly with Revit and does not import data to function. Insight 360 is a new technique that saves time by eliminating the need to import data and establish new projects and views. Insight 360 offers team members a dynamic and visual measure that shows how high-level modifications might alter a building's gross EUI without an in-depth grasp of energy flows or energy analysis tools. Insight 360, on the other hand, does not give extensive assessments. (Zhang et al., 2023)

Moving information from BIM to BEM today, as demonstrated by the case study, necessitates a significant degree of human coordination, which is inherently resource-intensive, error-prone, and irreproducible. Part of the problem is that BIM is designed for a certain discipline, often architectural representation or construction documentation. BIM modelers should consider that the model may be utilized to service different disciplines in the future; consequently, a uniform modeling technique is required. Furthermore, BIM software solutions can be better prepared to facilitate BIM's translation into an energy performance program. (Zhang et al., 2023)

C. Influence of the window factors on building energy demand

One of the essential methods for a low-energy or net-zero building is to optimize the building's envelope (windows, walls, and roofs) (Doe, 2001). The easy-to-use tool, such as BEM, has failed to give designers enough details about window factors (window size, position, material, and shadings).

D. Simulating a building energy demand and cost while using BEM

According to recent studies, BEM has become well-known among designers, developers, and homeowners, calculating the energy cost and consumption of the building.

Employing BIM as a data source for energy analysis makes the data input more well-organized and the current data more usable (Laine, Karola & Oy, 2007). In addition, BIM provides an interactive digital model connected with a simulation program so that designers can use and conduct energy evaluations simply within a software interface familiar with (Glassman & Reinhart, 2013). The most promising advantage is that exporting the energy estimation of the model can be done immediately, and modifications to the creation can be quickly incorporated (Kalavagunta, Jayaram & Naganathan, 2015). Utilizing BIM for predicting and estimating building energy use has failed to give its users more specific and critical data in reducing energy usage as designing has become more complex and demanding to save energy. Optimal estimation of window factors could result in more environmentally-friendly buildings, so window shading, materials, size, and position need specific data input to be valuable.

II. RESEARCH OBJECTIVE

The aim is to suggest simple strategies and techniques to designers to select window shading, material, size, and position. BIM energy modeling is not victorious in doing so in more detail, reducing building energy demand and consumption. As a result, the Cited items of the window were analyzed separately by a web-based tool, affecting the building energy use. The outcome will provide instructions for the designers and developers to choose window factors and pave the way for designing net-zero energy buildings. As in recent studies, the effect of these factors on building energy demand and use has been noteworthy. The BIM model is developed and adjusted by Revit® Energy simulation while using Green Building Studio ® platform for energy demand calculation connected to Revit®.

III. Methodology

A. Core model

To run the energy estimation tool of BIM, simulating an uncomplicated BIM model of a house is done (located in Kvemelto karti, Georgia (41.589868,44.867083)) (Fig. 1,2). This single-family house is a two-storied 134 m² house with a three-bedroom, two-bathroom, two living rooms, one dining room connected to the kitchen, one guest room, one study room, a staircase, and one store. Each room has windows.

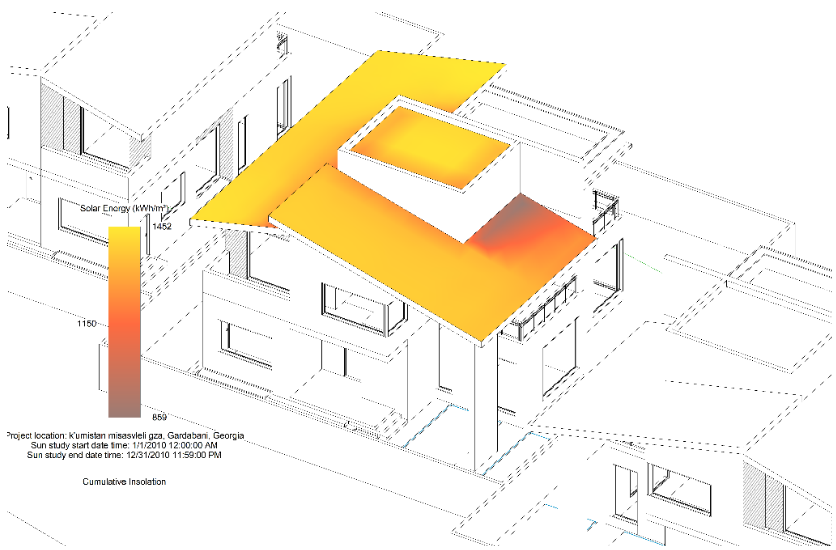


Fig. 1: The BIM model of the building

After creating BIM model of the building, and determining the utility rate of this region and its location, BEM has been used to gather data about window material Window to Wall Ratio (WWR), material and window shades.

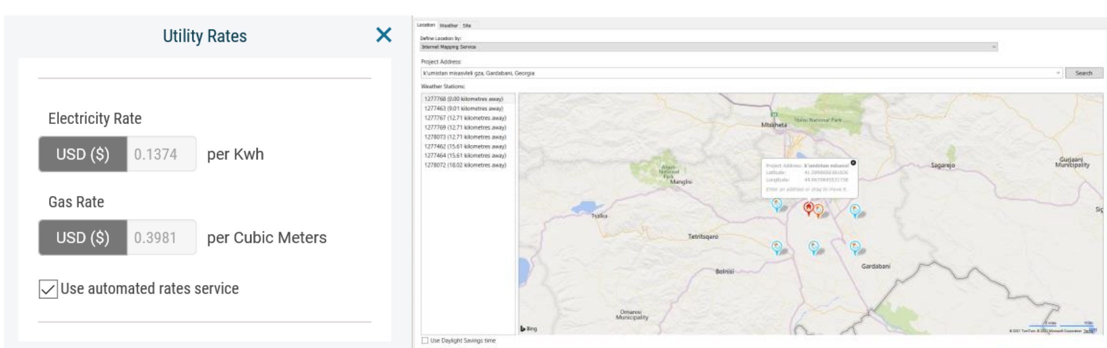


Fig. 2: a) the utility rates b); the house location in the map

By using this tool, users could have visual feedback of the overhang or vertical fins as well as an annual performance chart at the selected date and time (checking the window shades on the warmest (22 June) and coldest (22 December) day of the year in this region to find the best solution). The information provided by BEM is too general, not giving the best design solution for designing window shades. So, designers need to use this tool to reduce the time spent on other programming languages or software.

IV. RESULTS AND DISCUSSION

After modeling BIM, using the web-based tool for window shading and light penetration, and the linear programming for transportation problems, the tools reveal a need for more details when choosing window factors during the initial phases of design. The BIM tools used to help the designers to experiment with all possible design alternatives before the execution of the final simulation of this model could not keep up with the current needs to design a net-zero-energy building.

A. Analyzing BEM results

Window materials

Installing window material (either Dbl LoE or Trp LoE) could reduce the $3.14 energy cost and 61.84 kWh/m2/yr energy use to reach the standard energy cost and consumption (Table I). As glass properties control the amount of daylight, heat transfer, and solar heat gain into the building along with other factors, choosing double glazing – ¼ inch thick -clear/low-E (e = 0.05) glass for the windows could help save energy. However, this energy-saving cost does not motivate designers, constructors, and homeowners to choose this high-performance material for their windows to save energy and go through their shipping and material costs. A triangle displays the current state in Fig. 3.

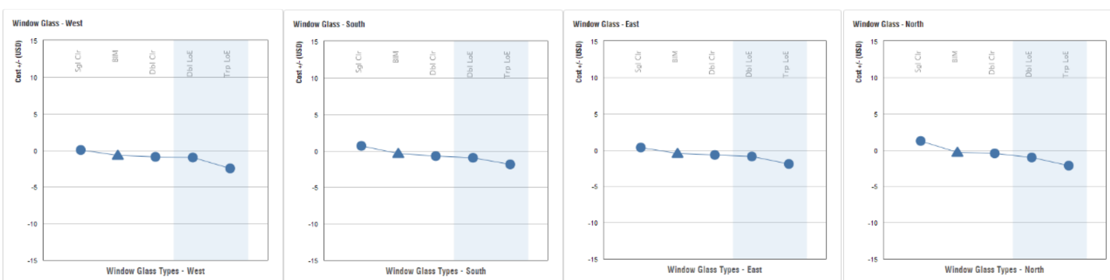
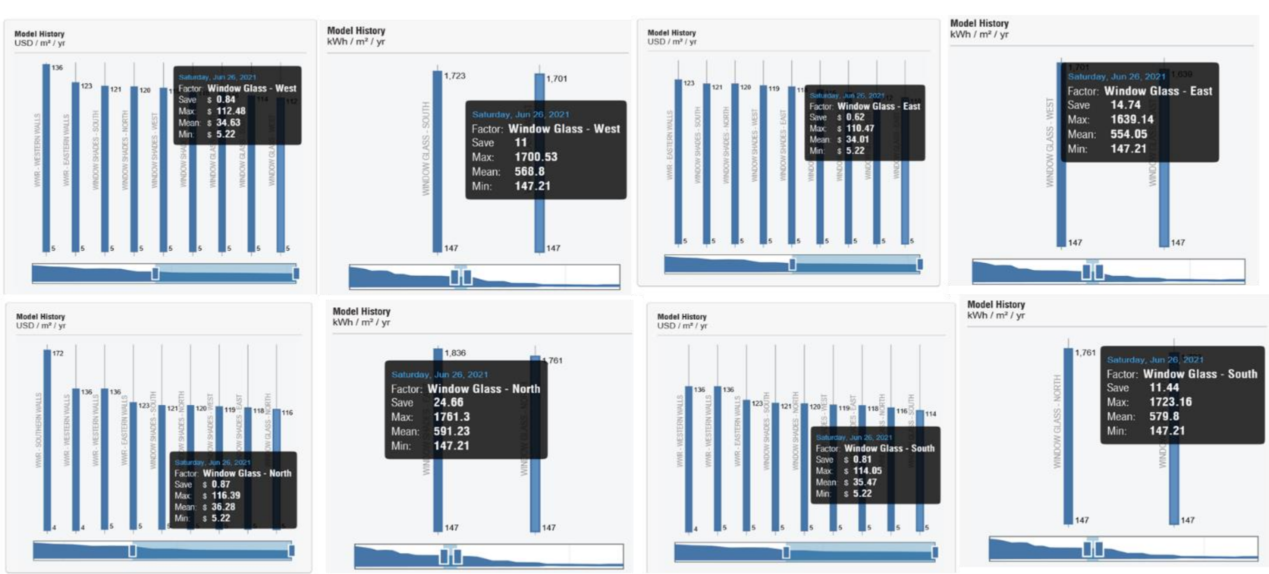


Fig. 3: Comparing the current energy cost of BIM default material with moderately high-performance glass to save energy a) window glass types-West; b) window glass types-South; c) window glass types-East; window glass types-North

This material has the most influence on the window facing north (Fig. 4). The problem is this energy analysis does not consider transportation problems based on the location of this house.



Logistics, supply chain, sustainability and global challenges
Vol. 13, Iss. 1, December 2022, 50-60
doi: 10.2478/jlst-2023-0004

Fig. 4: demonstrating energy cost and saving for different directions in terms of window materials a) energy cost saving for West; b) energy saving for West; c) energy cost saving for East; d) energy saving for East; c) energy cost saving for North; d) energy saving for North; c) energy cost saving for South; d) energy saving for South

Table I: Summary of energy cost and saving for each window material in different directions based on the outcome of Fig. 4

Window glass	**Energy-cost saving**	**Energy-use saving**
Window glass- West	$0.84	11 kWh/m2/yr
Window glass- East	$0.62	14.74 kWh/m2/yr
Window glass- North	$0.87	24.66 kWh/m2/yr
Window glass- South	$0.81	11.44 kWh/m2/yr
	SUM: $3.14	**SUM**: 61.84 kWh/m2/yr

Window shades

Choosing window shades ranging from 1/3 to 2/3 window height would reduce $1.7 energy cost and 9.21 kWh/m2/yr energy use to reach the standard energy cost and consumption (Table II). Window shades facing South would have more impact on energy costs and saving. The current state is shown as a triangle (Fig. 5).

Fig. 5: Comparing the current energy cost of window shades with different window shades to save energy a) window shades -West; b) window shades-South; c) window shades-East; window shades-North

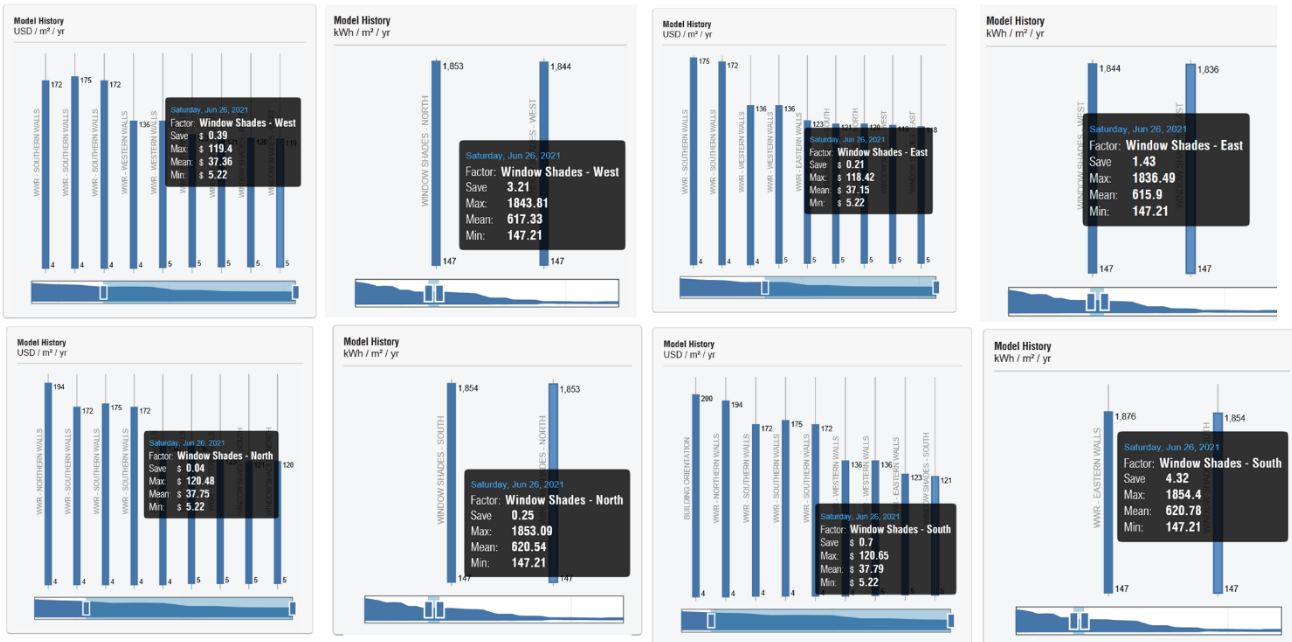


Fig. 6: demonstrating energy cost and saving for different directions in terms of window shades a) energy cost saving for West; b) energy saving for West; c) energy cost saving for East; d) energy saving for East; c) energy cost saving for North; d) energy saving for North; c) energy cost saving for South; d) energy saving for South

Table II: Summary of energy cost and saving for each window shade in different directions based on the outcome of Fig. 6

Window shades	**Energy-cost saving**	**Energy-use saving**	**size**
Window shades - West	$0.39	3.21 kWh/m2/yr	1/3 to 2/3 window height
Window shades - East	$0.21	1.43 kWh/m2/yr	1/4 to 2/3 window height
Window shades - North	$0.4	0.25 kWh/m2/yr	1/6 to 2/3 window height
Window shades - South	$0.7	4.32 kWh/m2/yr	1/3 to 2/3 window height
	SUM: $1.7	**SUM:** 9.21 kWh/m2/yr	

If more shadow is to be on the windows, the energy cost and savings would be better. In this case, a 2/3 window shade gives us the best results. The concern is that it does not give us enough information about the type and characteristics of window shadings so that they could be viable in the design. Using this general data would be time-consuming as it requires many simulations and calculations to estimate and run. Finding the perfect solution is arduous since it does not specify the window shadings' position, type, and size.

Window-to-wall ratio

Selecting Window to wall ratio ranging from 40%-15% would diminish the $11.64 energy cost and 150.03 kWh/m2/yr energy use to reach the standard energy cost and consumption (Table III). Window shades facing west would impact energy costs and savings significantly, thus minimizing these window shades. The current WWR marked by a triangle is 15% (Fig. 7) (current condition shown by BIM). Although the best option is 0% (without any openings), the need for openings for ventilation and view made us choose 15% WWR.

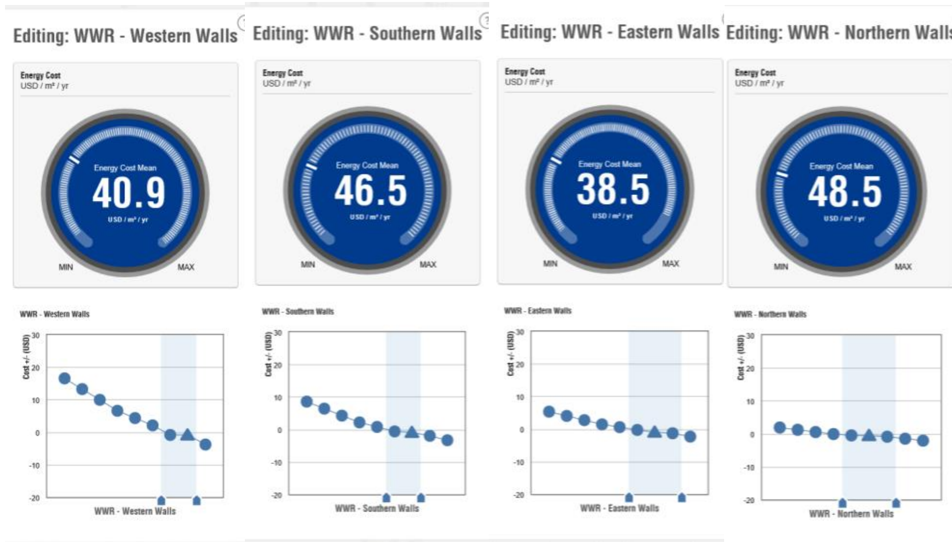


Fig. 7: comparing the current energy cost of WWR with different WWRs to save energy a) WWR -West; b) WWR -South; c) WWR -East; WWR -North

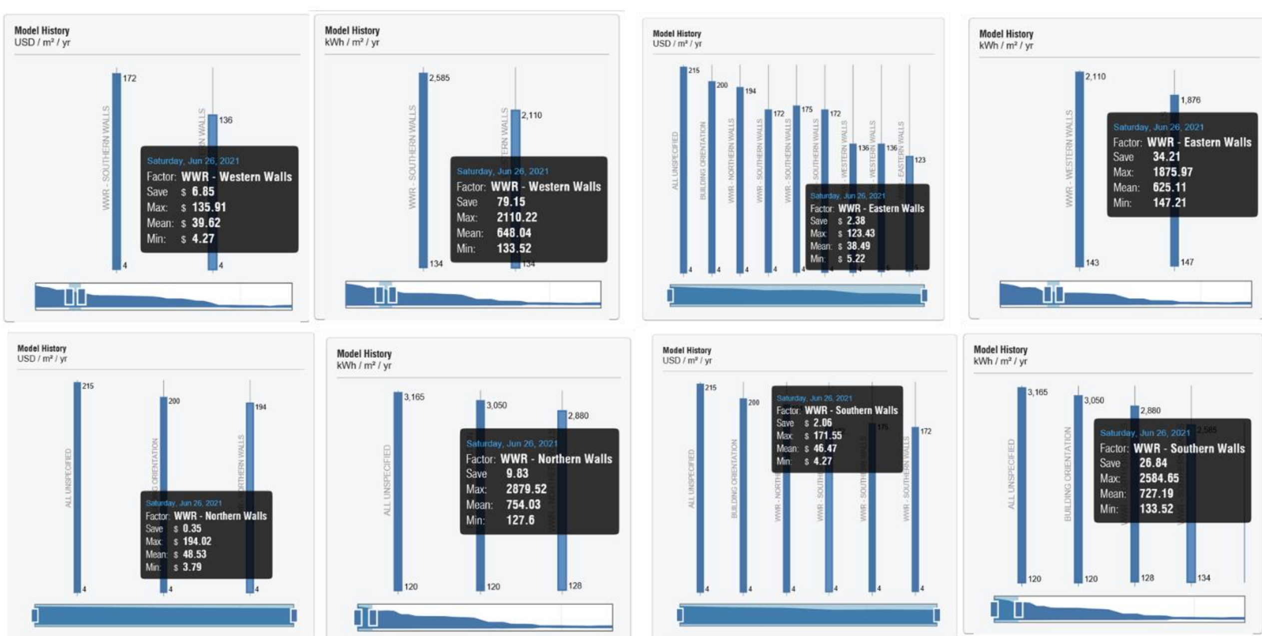


Fig. 8: Demonstrates energy cost and saving for different directions in terms of WWR a) energy cost saving for West; b) energy saving for West; c) energy cost saving for East; d) energy saving for East; c) energy cost saving for North; d) energy saving for North; c) energy cost saving for South; d) energy saving for South

Table III: Summary of energy cost and saving for each WWR in different directions based on the outcome of Fig. 8

Window-to-wall ratio	Energy-cost saving	Energy-use saving	size
the **Window-to-Wall Ratio** (WWR)-Southern walls	$2.06	26.84 kWh/m2/yr	range of 30% to 40% WWR

the **Window-to-Wall Ratio** (WWR)-Western walls	\$6.85	79.15 kWh/m2/yr	15% WWR
the **Window-to-Wall Ratio** (WWR)-Northern walls	\$0.35	9.83 kWh/m2/yr	range of 30% to 40% WWR
the **Window-to-Wall Ratio** (WWR)-Eastern walls	\$2.38	34.21 kWh/m2/yr	range of 15% to 30% WWR
	SUM: \$ 11.64	**SUM**: 150.03 kWh/m2/yr	

This ratio is to understand the percentage of optimized building glazing area. However, it does not give designers much information about the height and position of windows in the wall so that users have both thermal and visual comfort, making use of natural light and minimizing the use of energy.

For example, for bedroom window, sunlight during the day is desired and preferable as it will help to have a better sense of hour to do different activities. As a result, having natural light as much as possible in the room is recommended, especially when it is 8 a.m. till 4 p.m (during the coldest day of the year).

Different overhangs should be suggested in this program based on providing maximum shading during warm weather and entering the most natural light into the room during cold weather.

Checking light penetration items is imperative to select the best place for the window on different walls. Every window in this building should have data about light penetration based on their users' needs.

There is a need for a BIM energy analysis tool to propose the best type of shading for each window so that designers apply them to the windows, making sure that they are practical at the selected date and time (checking the window shades on the warmest (22 June) and coldest (22 December) day of the year in this region to find the best solution). Otherwise, designers should check out each window or use complicated algorithms. This practice would be too time-consuming, making it impractical or coercing them to return to the traditional way of using window shades. These methods are useless in saving energy and in providing natural light while having visual comfort.

The gap between data and designing strategies is conspicuous in the early stages of design in BEM.

V. CONCLUSION

The energy analysis tool reveals that the energy consumption per year significantly increases as the window size increases regardless of the window position.

The perfect design strategy decreases energy consumption by 37.5% and enhances thermal comfort by 33.5% compared to the initial draft. The exterior wall U-value should be at the center of attention throughout the energy-efficient design of the building envelopes followed by the U-values of roofs, windows, and the window-to-wall ratio (Shi, 2021).

BIM energy analysis tool known as BEM has gained more popularity among users than other tools, applications, and software, especially during the initial phases of the project; however, the connection between this data derived from BEM and design strategies is missing, causing users to extract this data and import them to other software, algorithm, and web-based tools. Exchanging data between them is time-consuming, thus, running other difficult-to-use programs for designing a net-zero building. The similarity between the predicted and actual results in terms of saving costs and energy could attract and ensure investors, homeowners, and stockholders to invest in these buildings.

Optimal window materials, transportation schedule, shades, and WWW minimize total energy load. Presented items should be devised and picked considering their impact on energy demand, visual comfort. Applying a web-based tool integrated with Revit should provide us with more details and background knowledge about practical window shading.

When suggesting materials for windows, there is little information about the transportation cost of materials and systems to the site, which could induce energy and environmental problems. The represented expenditure could change the determined materials previously chosen based on the thermal comfort of users.

VI. LIMITATION AND FURTHER RESEARCH

In the data energy analysis of BEM, the significance of window-to-wall ratio, window shading, and the place of windows is not transparent enough, so the provided information could be worthwhile when designing a net-zero energy house. There is a lack of easy-to-use energy analysis tools during the early stages of the creation of the project to find the best location for the window size, position, material, and shading to provide visual and thermal comfort. This optimization process requires an interactive design application between the building, its users, energy, transportation costs, and visual obstructions. It is also worth mentioning that the transportation cost of window materials and systems would influence the window materials and designs. These mentioned concerns need more research and data, which enables designers to use them conveniently. There are no available data on plants for users in their own country, especially developing countries, which could be used in energy analysis software when choosing materials and systems. As the building envelopes and forms are becoming more intricate and detailed, thus the comprehensive analysis of various window design factors should be part of BEM. There is a need for a more interactive design to show a more prescribed position of the window in the wall, especially for more complicated geometries, suggesting better types of shading instead of traditional ones (fixed overhangs or vertical fins). Visual comfort and lighting load should be considered, particularly in gigantic buildings where the impact of window size, shades, and properties would be more significant.

Declaration of interests

The author declares that she has no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper

I have no conflict of interests.

ReferenceS

Al-Tamimi, N.A.M., Fadzil, S.F.S. & Harun, W.M.W. (2011). The effects of orientation, ventilation, and varied WWR on the thermal performance of residential rooms in the tropics. *Journal of Sustainable development*, *4*(2), p.142.

Attia, S. (2011). 'State of the Art of Existing Early Design Simulation Tools for Net Zero Energy Buildings: A Comparison of Ten Tools', Architecture et climat. Louvain La Neuve, Belgium, (March), pp. 1–45.

Azhar, S., Brown, J. & Farooqui, R. (2009). 'BIM-based Sustainability Analysis: An Evaluation of Building Performance Analysis Software', in Proceedings of the 45th ASC Annual Conference.

Bazjanac, V. (2009) Implementation of semi-automated energy performance simulation: Building geometry, Cib W78.

Bernstein, H. M., Jones, S. A. & Russo, M. A. (2010) Green BIM McGraw-Hill Construction Green BIM SmartMarket Report.

Bokel, R.M.J. (2007). The effect of window position and window size on the energy demand for heating, cooling and electric lighting. In *Building Simulation* (Vol. 10). Delft: BS.

buildingSMART International (2016). buildingSMART Technical Vision. Retrieved 20 January 2018 from http://buildingsmart.org/standards/technical-vision/

Butts, D. (2016). Powering BIM—Capitalizing on Revit for Building Energy Modeling, Autodesk University. Retrieved 5 November 2017 from http://au.autodesk.com/au-online/classes-ondemand/class-catalog/2016/revit/mep19638#chapter=0

Digital Alchemy (2018). Digital Alchemy. Retrieved 5 January 2018 from https://d-alchemy.com/

Doe, U. (2001). Low-energy building design guidelines: Energy efficient design for new Federal facilities. *Federal Energy Management Program Booklet*, *7*.

Eastman, C., Teicholz, P, Sacks, R. & Liston, K. (2011). BIM Handbook: A Guide to Building Information Modeling for Owners, Managers, Designers, Engineers and Contractors. 2nd ed. Hoboken, New Jersey: John Wiley & Sons.

GbXML Inc (2018). About gbXML. http://www.gbxml.org/About_GreenBuildingXML_gbXML

Glassman, E.J. & Reinhart, C. (2013). Facade optimization using parametric design and future climate scenarios. In *Proceedings of the 13th Conference of International Building Performance Simulation Association, Chambery, France* (pp. 26-28).

Hitchcock, R. J. & Wong, J. (2011). 'Tansforming IFC Architectural View BIMS for Energy Simulation: 2011', in 12th Conference of International Building Performance Simulation Association. Syndney, pp. 1089–1095.

IESVE (2017). 'gbXML Shell Import Settings'. IESVE Help.

Kalavagunta, S., Jayaram, R. & Naganathan, S. (2015). Energy performance analysis of buildings in BIM workflow. *Renewable Energy*, *11*, p.13th.

Koohsari, A.M., Fayaz, R. & Kari, B.M. (2015). The influence of window dimensions and location on residential building energy consumption by integrating thermal and lighting analysis in a mild and humid climate. *BRIS Journal Of Advances in Science and Technology*, *3*, pp.187-194.

Laine, T., Karola, A. and Oy, O.G. (2007). Benefits of building information models in energy analysis. In *Proceedings of the Clima*.

Maurya, A., Kumar, R., Bharadwaj, U., Rawat, P. & Kumar, M. (2021). Sustainable Building Design: Energy Analysis of a Residential Building using AutodeskRevit. In *2021 2nd International Conference on Intelligent Engineering and Management (ICIEM)* (pp. 441-446). IEEE.

Mayouf, M. & Boyd, D. (2013) 'Exploring the Problematical Nature of Building Performance for BIM Representation', in ARCOM Doctoral Workshop. Birmingham City University, pp. 22–32.

Mohammed, A.B. (2022). Applying BIM to achieve sustainability throughout a building life cycle towards a sustainable BIM model. *International Journal of Construction Management*, *22*(2), pp.148-165.

O'Donnell, J. T. et al. (2013). Transforming BIM to BEM: Generation of Building Geometry for the NASA Ames Sustainability Base BIM.

Shi, M. (2021). Assessment of the impact of windows and building orientation on the energy intensity of container houses using BIM. In *IOP Conference Series: Earth and Environmental Science* 769(2), p. 022023).

Singh, V., Gu, N. & Wang, X. (2011). 'A theoretical framework of a BIM-based multi-disciplinary collaboration platform', *Automation in Construction* 20(2), pp. 134–144.

The American Institute of Architects. (2012). *An Architect's Guide to Integrating Energy Modeling in the Design Process.* The American Insitute of Architects

Trimble Inc (2018) *SketchUp.* Retrieved 22 January 2018 from https://www.sketchup.com/products/sketchup-free

Vladimir, B. (2001). *Acquisition of building geometry in the simulation of energy performance.* Lawrence Berkeley National Laboratory.

Wetter, M. & Van Treeck, C. (2017). *Annex 60: New Generation Computational Tools for Building & Community Energy Systems*.

Zhang, J., Zhu, X., Khan, A.M., Houda, M., Rehman, S.K.U., Jameel, M., Javed, M.F. & Alrowais, R. (2023). BIM-based architectural analysis and optimization for construction 4.0 concept (a comparison). *Ain Shams Engineering Journal*, p.102110.

Author

F. Boloorchi is with University of science and technology of Tehran in Iran, architecture department, (e-mail: fboloorchi@yahoo.com).

Manuscript received by 14 December 2022.

The authors alone are responsible for the content and writing of this article.

Analiza orodja za energetsko analizo (The Autodesk Insight 360) BIM v zgodnjih fazah procesa načrtovanja z vidika dejavnikov oken v enodružinski hiši

Izvleček – Pri načrtovanju ekoloških stavb imajo okna pomembno vlogo pri zmanjševanju energetske obremenitve. Tudi po številnih nedavnih študijah o okolju prijazni velikosti, senčenju, položaju in materialu oken še ni bilo enostavne programske opreme, ki bi pospešila postopek. Tako je bila simulirana enodružinska hiša s preprosto geometrijo v mestu Kvemelto karti v Gruziji, da bi predstavili alternativno metodo za obvladovanje te vrzeli. Za ta postopek je bil zasnovan informacijski model stavbe (BIM) s programom Autodesk Revit® zaradi njegove preprostosti, priljubljenosti, interoperabilnosti in priročnosti med uporabniki. Orodje za energetsko analizo (The Autodesk Insight 360) v programu Revit (BEM) prikazuje skupno energetsko obremenitev, pri čemer se v tem primeru osredotoča na velikost, položaj, material in senčenje oken, ki ga izvaja Autodesk Green Building Studio®. Zgodnja energetska analiza (optimalno razmerje med oknom in steno (WWR), položaj okna v steni, material in senčenje), ki jo predlaga BEM, ne daje dovolj informacij, ki bi jih lahko uporabili v zgodnjih fazah projektiranja in ustvarili stavbo z ničelno neto porabo energije. Cilj je prikazati vrzel med podatki, pridobljenimi iz BEM, in strategijami projektiranja ter prikazati potrebne podrobnejše informacije. V ta namen je bilo po uporabi orodja Insight 360 (spletno orodje) za preučevanje okenskih senčil, materiala in WWR ugotovljeno, da je potreben priročnejši način za bolj poglobljeno avtomatizacijo postopka. Z njimi bi lahko pomagali pri izbiri ustreznega senčila vdove, velikosti, položaja in materiala. Poleg tega izbira določenih dejavnikov samo z uporabo BEM ni praktična, ker podrobne značilnosti okenskih dejavnikov kot določevalnih elementov niso opredeljene. To orodje ima svoje omejitve.

Ključne besede - velikost okna, material okna, senčila, položaj okna, BIM, Autodesk Insight 360