WWW.IJRPR.COM

International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

A Review on the Building Energy Modelling and Orientation using BIM

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A B S T R A C T

The growing concern for energy conservation and environmental sustainability has encouraged the development and integration of BEM and BIM technologies. This comprehensive review explores the synergistic use of Building Information Modelling (BIM) for Building Energy Modelling and the impact of building orientation on a building's energy performance. BIM's role in facilitating early-stage energy analysis, improving collaboration, and supporting lifecycle assessment is discussed. The significance of building orientation in optimizing energy efficiency is highlighted. The review emphasises BIM's capacity to analyze and optimize building orientation through simulations to maximize passive heating and cooling opportunities. Real-world case studies illustrate successful applications of BIM for energy modeling and orientation optimization, showcasing achieved energy savings and sustainability gains. Overall, the review underscores the indispensability of BIM in designing energy-efficient buildings and promoting sustainability in the Architecture, Engineering, and Construction (AEC) industry.

Keywords: Building Information Modeling (BIM), Building Energy Modeling, Orientation, Sustainability.

Introduction

In recent years, the construction industry has witnessed a paradigm shift towards sustainable building practices and energy-efficient designs. As part of this transformation, BIM has emerged as a powerful tool that enables architects, engineers, and energy specialists to analyze and optimize building energy performance. This review explores the synergistic relationship between BIM and Building Energy Modelling (BEM), with a specific focus on the impact of building orientation on energy efficiency.

BIM, which stands for Building Information Modelling, is a revolutionary approach to the design, construction, and management of buildings and infrastructure projects. It is a digital representation of a building's physical and functional characteristics, providing a collaborative platform for various stakeholders involved in the construction process. In traditional construction methods, each discipline (architects, engineers, contractors, etc.) would work independently, leading to potential inefficiencies, errors, and communication gaps. BIM, on the other hand, brings all these disciplines together in a coordinated and integrated manner. Key features of BIM include 3D Visualization, Data-Rich Models, Collaboration and Coordination, Clash Detection, Lifecycle Management, Cost and Schedule Estimation, sustainability, and Energy Analysis.

Building Energy Modeling is a crucial component of the broader field of Building Information Modeling (BIM) that focuses specifically on the energy performance analysis of buildings. BIM, as mentioned earlier, provides a digital representation of a building's physical and functional characteristics, while BEM takes this one step further by analyzing and simulating the building's energy consumption, thermal performance, and overall environmental impact. Energy analysis with BIM and BEM involves the use of specialized software tools to create a virtual model of a building, enriched with data about its components, materials, and systems. This data includes properties like insulation values, glazing types, HVAC (heating, ventilation, and air conditioning) systems, lighting fixtures, and more.

A key focus of BEM, when paired with BIM, is evaluating the impact of building orientation on energy efficiency. The direction a building faces relative to the sun can profoundly influence its energy performance. Optimal orientation can maximize natural daylighting, harness solar energy for heating purposes, and minimize heat gain during hot periods, ultimately reducing the need for artificial lighting and mechanical cooling systems. A key focus of BEM, when paired with BIM, is evaluating the impact of building orientation on energy efficiency. The direction a building faces relative to the sun can profoundly influence its energy performance. Optimal orientation can maximize natural daylighting, harness solar energy for heating purposes, and minimize heat gain during hot periods, ultimately reducing the need for artificial lighting and mechanical cooling systems.

Moreover, BIM's parametric capabilities enable architects and engineers to explore multiple design scenarios quickly. By adjusting the building's orientation within the BIM model, professionals can evaluate the impact on energy consumption and occupant comfort iteratively. This iterative approach fosters creativity and innovation in designing energy-efficient buildings. The integration of BIM with BEM also enables clash detection, not only in terms of spatial coordination but also in identifying clashes related to energy efficiency. For instance, BIM can help identify instances where a building's orientation may result in excessive solar heat gain on specific building components, prompting design modifications to mitigate such issues. Furthermore, the synergy between BIM and BEM plays a vital role in achieving sustainability certifications like LEED. Building orientation is a key consideration in energy performance, and BIM allows for the documentation and visualization of energy-related design strategies, simplifying the certification process.

Ultimately, the collaborative nature of BIM facilitates better communication and decision-making among project stakeholders. Architects, engineers, energy consultants, and clients can work together seamlessly, ensuring that energy considerations are integrated from the early design stages. This leads to more informed decisions that align with energy efficiency goals.

Review of Literature

[1] Framework for Using Building Information Modeling to Create a Building Energy Model

The paper suggested a framework that enables professionals to create BIM and BEM to complete energy analysis during the design process. A trail investigation is done on a two-storey building that is modelled in Revit (BIM) and transferred to IES-VE (BEM) via gbxml format. During the transfer, several interoperability issues were identified. Further, the proposed framework is evaluated using a case study of a six-storey building to determine if it is applicable to different BEM tools. For this, Revit is used as a BIM tool, and Open Studio is used as a BEM tool. They are connected through the IFC format. Finally, the energy analysis is performed using Energy Plus, confirming that the framework is also functioning for Open Studio and IFC

[2] Evaluation of BIM energy performance and CO2 emissions assessment tools: a case study in warm weather.

In this paper, the authors have done research on the energy performance of the building. The main objective of this paper is to evaluate the energy performance and CO2 emissions of the building by comparing the results of different software. Knowing the performance of a building in the design stage will affect the cost of the building and be helpful in making design alterations to get the best performance from the building. Initially, they modelled the building in REVIT, and then they evaluated the performance of the building in two stages: the initial stage and the advanced stage. They also evaluated the CO2 emissions during the duration of construction. They performed an energy analysis on the building in different software named GBS, IESVE, HULC, Sefaria, and Design Builder. They compared all the results, and based on that, they concluded that design builder software gives the best results, i.e., is very close to real-time data. these energy performance evaluation analysis tools can be useful in the process.

[3] An investigation on energy consumption in residential building with different orientation: a BIM approach.

This Paper targets to provide Simplified energy analysis the influence of the orientation of the buildings. The Consider a multi-stored, multifamily residential house at Afghanistan. The framework of this process is done in step-by-step process by using energy analysis tools. By using BIM software with inbuilt energy evolution tools, the building model is generated in Revit and then it taken to GBS by help of exported the gbXML file. By using Insight 360° they done the orientation of building in 360° in a divided by tested by 24 sides starts with 15° and ends with 360°. The results showed a cost saving of the best orientation +315 [4].

[5] Analysis and evaluation of energy efficiency in buildings based on Building Information Modelling.

In this paper the author investigated on the Analysis of evaluation of the energy efficiency of one operational on the educational building located in Guagapuil Evadar (+2-88°from the north) They do the analysis on the parameters like orientation, types of walls, roofing, solay energy analysis, construction materials and atmospheric data survey is conducted on the building. By using Revit (BIM Software) they done the building modelling in 3D, then the passive constructive characteristics of the building are parameterized an analysis of energy using Insight 360 software and efficient energy with green construction materials are proposed with Green Building Studio (GBS) analysis by software which to a flexible cloud-based service Its it predicts the energy use and cost for the building. The building is tested by six orientations (2.88 degree +45°, 96 + 180°-45 °& 90°) and energy analysis 1(12/7, 24/7 ,12/6 8 12/5) in hours of the current operation of the building. The results shows that 180° scenario with 0.32% of better performance & the 12/5 scenario has the best energy performance is best orientation of reducing the energy.

[6] Evaluation of energy use intensity (EUI) and energy cost of commercial building in India using BIM technology.

In this paper the author Study on the Energy Use Intensity (EUI) as well as energy cost on the building. In this study they Considered a commercial building located in Vadodara City, Gujarat in India. Modelling of the building is performed by utilizing the Autodesk Revit Architecture, and further for energy analysis the Autodesk Insight is used for the orientation These study targets are to provide energy efficiency of the building by varying different design strategies with respect to EUI and energy cost based on their standards. It is observed that with the minor variation in design strategies causes large percentage of differences in the EUI as well as energy cost [7].

[8] Using Building Information & Energy Modelling for Energy Efficient Designs.

This paper mainly focuses on the multiple factors that must be considered to accurately predict a building's energy requirements for lighting and overall consumption. These factors include energy-saving techniques, the use of energy-saving strategies, and the impact of building information modelling (BIM) and Autodesk Revit on energy consumption. Additionally, the analysis should take into account the specific amount of energy used for building operations. The first step would be to conduct a thorough assessment of the energy efficiency measures already in place, evaluate the lighting setup, identify areas for improvement, and implement energy-saving technology. Examples of such technologies include LED lighting, motion sensors, and smart lighting controls, all of which are designed to minimise energy usage and maximise illumination.

[9] Multicomponent Energy Assessment of Buildings using Building Information Modelling.

This paper gives a detailed outline of how the adoption of novel strategies that make use of cutting-edge software solutions by developers and designers is crucial to achieving the highest levels of energy efficiency in residential structures. They may transform their projects into extremely energy-efficient

and sustainable buildings by including tools like Green Building Studio (GBS) and Autodesk Revit in their building design process. Utilising advanced software programmes like GBS and Autodesk Revit, which provide strong capabilities to analyse and optimise building energy performance, is the first step towards achieving this goal. For example, GBS is a specialist tool for energy analysis that assists in determining how much energy is used by buildings through various simulations and calculations [10].

[11] Assessment of the Impact of Window Size, Position and Orientation on Building Energy Load Using BIM.

In this paper, the authors give a detailed view of orientation and materials throughout the energy simulation process to improve energy efficiency in building design. By including these components, designers can start testing and evaluating the building's energy efficiency. The building's orientation should be optimised to best utilise available natural resources and ensure long-term energy efficiency. Energy simulations become a crucial tool to evaluate the building's potential energy performance throughout the early design phases. They can pinpoint potential weaknesses and areas for advancement in terms of energy consumption during this experimentation period.

[12] Analysis of risk in building life cycle coupling BIM-based energy simulation and semantic modelling.

In this paper, the authors discuss how Residential buildings must combine physical changes to the structures with the incorporation of cutting-edge software solutions in order to reduce energy use and improve efficiency. Developers can considerably improve the energy performance of their buildings by integrating Green Building Studio (GBS) and Autodesk Revit into their design and construction processes. Changes to the physical aspects of the buildings must be made first. This entails carefully taking into account the architectural style, positioning, and arrangement of the buildings. The demand for artificial lighting during the day can be decreased by developers by strategically placing windows and maximising the use of natural daylight, which will lead to lower energy consumption. The use of energy-efficient materials and proper insulation helps maintain cosy interior temperatures and reduces the need for unnecessary [13].

[14] Building Information Modelling-Based Building Energy Modelling: Investigation of Interoperability and Simulation Results.

From this paper, I understood that adopting a common file format, such as gbXML, is particularly helpful for the seamless integration of Building Information Modelling (BIM) and low-energy applications through energy modelling. The use of Revit's software tools can be made more effective by employing the gbXML file format, leading to the design of structures with higher energy performance. This file format streamlines the energy modelling process and makes it easier to interchange data between various BIM tools, improving interoperability. The gbXML file format may be easily utilised by Revit, a popular BIM programme, to import and export building data. To maximise the building's energy efficiency throughout the design phase, this enables architects and engineers to carry out energy modelling and analysis within the Revit environment. Professionals can precisely implement HVAC system extensions that are compliant with the GBXML format. The implementation of Autodesk Revit Insight 360 is highly recommended. Insight 360 is a powerful cloud-based tool that complements Revit's capabilities by providing advanced energy analysis and simulation.

Conclusion

In conclusion, the integration of Building Energy Modeling (BEM) and Building Information Modeling (BIM) offers a transformative approach to enhance building energy efficiency and sustainability. Through BIM's collaborative and parametric capabilities, stakeholders can conduct early-stage energy analysis and make informed decisions to optimize a building's energy performance. Building orientation emerges as a critical factor in achieving energy efficiency, and BIM's simulation tools enable the identification of the most optimal orientation by considering solar access, wind patterns, and shading.

Real-world case studies presented in the review showcase the tangible benefits of BIM in energy modeling and orientation optimization. These successful applications have resulted in significant energy savings, improved indoor comfort, and reduced environmental impact. The review emphasizes BEM and BIM's instrumental role in promoting energy-efficient and environmentally responsible building design and construction. As the AEC industry continues to prioritize energy conservation and sustainability, the integration of BEM and BIM is expected to become even more vital. With ongoing advancements in technology and software, the seamless collaboration and simulation capabilities offered by BIM will further empower professionals to create energy-efficient and sustainable buildings. Overall, this review highlights the critical importance of leveraging BEM and BIM to pave the way for a greener and more sustainable built environment

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