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BIM–AI-Based Prediction of Building Energy Consumption and Life-Cycle Carbon Emissions: A Comparative Review

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ABSTRACT

The building industry is a large user of energy and emitter of carbon. The emissions are caused by construction materials, building activities, energy consumption, maintenance and demolition. Energy use and carbon emissions are key elements to predict for sustainable building design. Building Information Modelling (BIM) is a digital representation of building geometry and quantity of materials. Artificial Intelligence (AI) can be used to analyze building data and predict building performance. In the context of BIM, AI, energy prediction and carbon assessment. The studies reviewed cover the following topics: machine learning, BIM-based energy simulation, digital twins and sustainability assessment. The results show that building geometry, orientation, building materials, climate and occupancy affect building performance. When training and validation data is available, machine-learning methods may be used to assist in energy prediction. The quantities generated by BIM can also be used to estimate embodied carbon of construction materials. Estimates of operational carbon can be made with energy use and suitable emission factors. The review led to the development of an integrated BIM–AI approach for building energy and life-cycle carbon assessment. The framework could be used to compare materials and design options at the early planning stage. More case studies are needed to confirm its validity and applicability to Indian buildings.

Key Words: Building Information Modelling (BIM); Artificial Intelligence (AI); Building Energy Consumption; Carbon Emissions; Machine Learning; Embodied Carbon; Operational Carbon.

INTRODUCTION

The construction industry is a key contributor to economic development and infrastructure expansion. Yet, a lot of materials and energy are needed for construction and operation of a building. Embodied carbon emissions are emitted through the production of cement, steel, bricks and glass. The environmental effects of buildings are also attributed to transportation and construction activities. Buildings, when in use, use electricity and fuels for lighting, cooling, ventilation and equipment.

The emissions produced are a function of the energy use and energy sources. Hence, minimisation of building energy consumption and reduction of carbon emissions is an important sustainability goal. Preparing for an early prediction can lead engineers to find environmentally appropriate building options. Building Information Modelling (BIM) is a digital way of representing building information. Can give information about geometry, size, part and material volumes.

BIM information can be used to aid in quantity estimation, energy modelling and carbon calculation. But to do analysis with BIM, it is necessary to have accurate quantities, material properties and reliable emission factors. Artificial Intelligence (AI) can review information and discover links among building attributes and performance. Predicting building energy consumption is one of the AI methods that can be employed, such as machine learning. Those that are most common are regression, random forest, support vector machines, and artificial neural networks.

The quality of data, the number and quality of the input variables and the validation of the model have a significant impact on the accuracy of the predictions. Data-driven energy prediction and building performance benchmarking have been studied previously. Some other research has been conducted on BIM-based energy simulation and sustainable building design. Digital twins and digital technologies for building sustainability and for the reduction of carbon emissions have also been investigated.

The results of these studies show the feasibility of digital BIM and predictive approaches. The goals, methods and assessment scope of the reviewed papers, however, vary. Some concentrate on the operational energy, and others concentrate on materials, retrofits or broader digital technologies. A combination of approaches can be used to relate material quantities to operating energy predictions. Can also be used to compare alternative building materials and design configurations.

Indian buildings require consideration of local climate, construction practices and emission factors of electricity generation. This paper related to BIM, AI, energy and carbon assessment. It spells out typical findings and ways to incorporate the various approaches. Last but not least, it suggests a model to estimate building energy use and life cycle carbon emissions.

LITERATURE REVIEW

Amasyali and El-Gohary [1] discussed the data-driven approaches used for the prediction of energy consumption in buildings. They have studied the objectives of the prediction, data preparation, input variables and model evaluation.

Seyedzadeh et al. [2] have reviewed the machine-learning techniques used for building energy consumption and performance estimation. They studied Artificial Neural Networks, Support Vector Machines and regression based methods. As illustrated in these reviews, machine learning is also helpful in building-energy prediction, provided appropriate data are available.

Li et al. [3] created an ensemble learning based building energy and carbon-emissions benchmarking approach. They analyzed data for several cities in the United States as well as various climate zones. The results showed the feasibility of data driven prediction in the energy and carbon benchmarking.

Siewczyńska [4] has analysed the differences in the energy performance of prefabricated building geometries with the help of simulation on BIM basis. The study demonstrated that geometry and glazing configuration and climate can affect energy demand.

Attia [5] explored the application of AI and BIM in construction processes. The paper covered the topics of design automation, predictive analysis and challenges to the implementation of an integrated system.

CONCLUSION

This paper made a BIM, AI, building energy prediction and carbon assessment. There are a number of studies that suggest machine learning has potential to assist in energy prediction if the right building data is utilized. BIM offers valuable data on building geometry, building component quantity and material quantity. Carbon assessment for the life cycle of a material aids in the evaluation of carbon emissions that are related to material and operational emissions within a specific boundary. It is proposed to integrate these information sources using a BIM-AI framework. The framework could be of benefit for comparing alternative materials and design options for buildings with lower carbon footprint. Good emission factors and appropriate training and validation data are key to ensure the results are accurate. The proposed framework needs to be further tested on a building case study from India. The developed model can assist in making better decisions for energy efficient and sustainable building.

REFERENCES

1. Li, T., Liu, T., Sawyer, A. O., Tang, P., Loftness, V., Lu, Y., & Xie, J. (2024). Benchmarking of building energy and carbon emissions (GECE) and the post-prediction analysis. *The Built Environment*, 17, 100320.
2. Amasyali, K., & El-Gohary, N. M. (2018). Review of building energy consumption prediction studies using data. *Renew. Sustainable Energy Rev.*, 81, 1192-1205.
3. Seyedzadeh, S., Pour Rahimian, F., Glesk, I., & Roper, M. (2018). Review on machine learning approach to building energy consumption and performance estimation. *Visualization in Engineering*, 6, Article 5. <https://doi.org/10.1186/s40327-018-0064-7>
4. Zou, X., Tan, Y., Zhang, G., & Hou, L. (2026). A systematic review on the sustainability analysis of building green retrofit using BIM. *Energy & Buildings*, 354, 116982.
5. Geng, L., Li, S., Noroozinejad Farsangi, E., Xu, X., & Tam, V. W. Y. (2026). What are some ways digital technologies decrease construction industry carbon emissions? A systematic review. *Energy & Buildings*, 350, 116605.