



BIM-Integrated Sustainable Buildings: An Integrated Approach to LEED Zero Energy, Zero Waste and Zero Water

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ABSTRACT :

Energy consumption and waste generation, water usage and greenhouse gas emissions are significant in the building construction industry. This paper presents an integrated conceptual approach of three Zero goals of LEED – Zero Energy, Zero Waste, and Zero Water with Building Information Modeling (BIM). To use resources during the building's life cycle, BIM allows for coordinated design, energy analysis, quantity take-off and water planning according to a model specified workflow.

Key Terms: Sustainable Buildings, LEED, LEED Zero Energy, LEED Zero Waste, LEED Zero Water, Building Information Modeling (BIM), Rainwater Harvesting, C&D Waste, Life-Cycle Assessment, Resource Efficiency.

INTRODUCTION

The building and construction sector consumes a considerable amount of energy, water and materials and generates a substantial amount of construction and demolition waste and GHGs. The traditional construction methods heavily depend on non-renewable energy, potable water and recently produced materials, resulting in high environmental impacts of the construction industry, which is a prerequisite for the development of sustainable alternatives. Sustainable buildings encourage design, construction, operation and maintenance that minimizes potential environmental impacts, recognizing resource efficiency and occupant comfort. There are many green building rating systems which rate the building's performance in terms of its energy use, water use, materials management and environment such as Leadership in Energy and Environmental Design (LEED).

LEED Zero is a series of standards that recognize a project's efforts to achieve net-zero on a particular resource. Zero Energy is about reducing demand, and meeting the rest of that demand with energy generation from renewable sources. Zero Waste is about eliminating waste by preventing, reusing and recycling waste to be diverted from landfills. Likewise, Zero Water aims for net zero potable water use by taking into account efficiency and alternative sources. The goals are by no means mutually exclusive; they should be taken in conjunction, as energy and materials are used in the process of treatment of water, while emissions may influence the material production.

Building Information Modeling (BIM) is a digital process that contributes to the creation and administration of information related to a built facility throughout its life cycle. It includes the geometric shape of the building, the materials, quantities, and systems specifications. BIM offers opportunities to explore sustainable design options such as energy analysis, material calculations, waste prediction, and water management to aid decision-making prior to construction. This paper aims to discuss the integration of these three zero objective as literature review on conceptual level.

LITERATURE REVIEW

LEED is the widely-used U.S. Green Building Council green building rating system. Riad et al. (2026) have done a comparative study of LEED v4.1 and v5 based on a case study of an academic building retrofit. Their analysis underlined the growing demand for carbon reduction, resiliency, and life-cycle approaches in green building evaluation, and the need for a coordinated sustainability strategy, extending beyond the individual rating categories.

The goal of a zero energy building is to reduce energy consumption by improving building envelope performance, adding high performance glass, energy efficient lighting and heating, ventilation, air conditioning (HVAC) systems, and to use more natural light and more solar PV energy on the roof than is used. The Joyce Centre for Partnership and Innovation at Mohawk College was assessed by Bhavsar, Cupido and Arriaga for its net zero energy and zero carbon institutional building. Operational data can confirm that the building has achieved the net zero status, BIM can be used to analyse the building geometry, orientation and materials to assist with informing decision making processes.

Meanwhile, construction and demolition waste (C&D) are those generated by building and demolition works, such as concrete aggregates, metals, timber, glass and plastics. If waste management practices are not appropriate, C&D waste may be incinerated in landfills, resulting in the emission of greenhouse gasses. If waste management practices are inappropriate, C&D waste can end up in landfills increasing the emission of greenhouse gasses. Kucucvar et al. (2016) investigated the recycling alternatives for construction waste from a LEED registered university building, through the life-cycle assessment method. They found that the benefits of recycling are dependent on the kind of material recycled, as recycling of metals, cardboard and glass are favourable, but concrete can have a greater carbon emission due to fuel used in concrete crushers. Bao et al. (2020) carried out a study on the building

sustainability of LEED certification in China and found that LEED certification is not always an indicator of good waste management due to regulatory differences and differences in the economic incentives. BIM can help to develop a zero-waste strategy by providing information to the construction team regarding the quantities of building materials, provide pre-fabricated detailing and manage waste records.

The water management is one of the most important issues of sustainable building as conventional buildings consume extensive quantities of potable water on site for a wide range of applications. Use of water efficient fittings, reusing rain and greywater and finding and fixing leaks and meters can reduce potable water consumption significantly. Alawneh et al. (2019) studied the relationship between LEED water efficiency and energy criteria and the United Nations Sustainable Development Goals in the context of Jordan, highlighting the significance of water and energy efficiency. BIM can be used to help the construction teams determine the installation of the water fittings, forecast the rain water demand, and strategies for water storage and reuse.

The three zero targets are clearly linked and can be addressed with a common BIM-based approach from conceptual design to take building orientation and materials into account, through detailed design to ensure systems coordination, during construction to compare designed quantities and waste records and, last but not least, during operation to compare meter data in-built in the model. The literature reviewed deals with each of the three areas, or with a specific example. An important opportunity is to coordinate the zero energy, zero waste and zero water solutions on a common BIM-based platform and include a tool for the reduction of energy use intensity, diversion rate, potable water, etc., that can be validated with operational data.

CONCLUSION

LEED Zero Energy, Zero Waste, and Zero Water are integrated and are coordinated with each other to avoid offsets. BIM provides a shared digital environment to resolve energy analysis, waste planning and water management, as well as to ensure greater communication and earlier problem identification. The feasibility and practical application of this framework needs to be demonstrated in a chosen building project, with a comparison of the energy, waste and water results projected with the energy, waste and water results from the operation of the building to determine the feasibility.

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