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The Benefits and Challenges of Building Information Modelling (BIM) in Green Building

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Abstract

Recently, numerous issues on the environment have been debated locally and globally. This global phenomenon hit Malaysia as well. Malaysia is now concerned about green issues, whether greening cities or buildings. From establishing the Green Building Index (GBI) in 2009 until now, Malaysia has been moving forward to achieve its sustainability goals. Building Information Modelling (BIM) is one of the tools which can facilitate various functions before, during and after the occupation of the building. Therefore, the idea is to integrate green and BIM to prepare the new building as a green-certified ready. The method used to retrieve the information is a literature review focusing on BIM and green initiatives. The data is then computed and rearranged using the thematic topic to separate the main issues. Based on the literature reviews, it is found that the BIM and green initiatives can be integrated to achieve sustainability and aspiration of Industrial Revolution (IR) 4.0 and Sustainable Development Goals (SDG).

Keyword: Building Information Modelling, Green Initiative, Green Building Assessment Tools, Green BIM

Introduction

Today most of the clients concerning with green building certified issues. The certification of green building will be given to the building which fulfilled all the criteria imposed by the green building assessment tools (GBAT) provider. Each country has its GBAT, and each GBAT has its criteria and might vary from each other. For instance, BREEAM in the United Kingdom, LEED in the US, CASBEE in Japan, SB Tool in Canada, EGSB in China, Green Mark in Singapore, Green Star in Australia and Green Building Index (GBI) in Malaysia. However, the numbers of GBAT have not been mentioned in this paper, but the main objective is to certify the building to be a green building. Current practises and research on green buildings evolved where the designers and the researchers tried to integrate the green building with Building Information Modelling (BIM).

BIM has been introduced to architecture engineering and construction (AEC) since the 1970s. The project's complexity is one of the reasons why BIM is needed in construction projects. The primary function of BIM is to design, plan, build, manage and manage the building after the construction projects are completed. Early involvement of BIM in the preliminary stages can predict the problems that might arise during the construction phase. Hence this can prevent the construction projects from being delayed and cost overruns. Even though BIM was used in construction a long time ago, the acceptance rate of using these tools is still low. However, the Malaysian Government had taken one step higher when it announced that construction projects worth 100M and above are compulsory to use BIM tools from 2020 onwards. Hopefully, these regulations will kick the construction stakeholder to take this opportunity to move towards IR 4.0 aspiration.

The current industry challenges led the authors to select BIM as an appropriate tool for the construction industry to incorporate green initiatives into their existing workflow as a holistic solution for sustainability. BIM supported functions for green issues: energy performance analyses, carbon emission analyses, natural ventilation system analyses, solar radiation and lighting analyses, water usage analyses, acoustics analyses and thermal comfort analyses (Lu et al., 2017). This paper aims to investigate the benefits and challenges of the implementation of green BIM in construction projects.

Problem Statement

Integrating BIM and green initiatives"Green BIM" is a concept comprising a BIM-based sustainable design and green building practices to attain sustainable objectives in a project (Krygiel & Nies, 2008). With the gaps between industry needs, available academic research, and our current conceptual understanding of deficiencies, a review of existing green BIM development is needed (Wong & Zhou, 2015). Therefore, this research aims to critically review and document the development of BIM and green initiative for the building project.

Although lean, green and BIM have their respective benefits and capabilities to address the problems faced by the construction industry today, an amalgamation of these paradigms is now needed (Ahuja et al., 2017). The use of BIM throughout the lifecycle of built environment projects can enhance the lean and green benefits. Smart Market report from McGraw Hill Construction (2009) has suggested that BIM adoption leads to a wide range of lean benefits, including improved productivity, enhanced quality, increased opportunities for new businesses, and better project outcomes. BIM can support green buildings during planning, design, construction, operation, and maintenance (Khoshdelnezamiha et al., 2019). Motivated by this background, this research explores the potential benefits of integrating BIM and green initiatives for sustainable building projects.

An online survey conducted by McGraw-Hill Construction in 2010 investigated a wide range of industry professionals who use BIM tools to deliver green buildings, showing that BIM could significantly facilitate green construction. It is expected to be extensively used in the future if relevant challenges can be identified and effectively tackled (Lu et al., 2017). However, Memon et al (2014) argued that BIM implementation is very slow in the Malaysian construction industry. This slow implementation is caused by human and technical barriers, known as internal and external barriers. Hence this research will identify the challenges in integrating BIM and green initiatives for the sustainable building project.

Methodology

This paper is a review paper that primarily obtained its sources from relevant established journal articles, conference papers, books, etc. The content enclosed the keywords "building information modelling," "green initiative," "green building assessment tools," and "green bim." Based on the keywords given, the author focus on the objectives of this paper, namely, to identify the potential benefits and the challenges of implementing Green BIM. This paper reviewed references within six to seven years to ensure that the information retrieved and given is current. However, it is exceptional for specific information in many sources that contain a narrative or historical background of BIM or Green BIM. The preferable information was presented in this paper's result and discussion sections reviewing the sub-topics of BIM and Green BIM previous studies and the benefits and challenges of the Green BIM approach in the construction industry.

Literature Review

Building Information Modelling

Research into BIM has a long story. It started with the name Building Description System (BDS), introduced by Eastman et al (1974), and was named BIM in 2011. The following diagram shows the evolution of BIM from beginning to date.

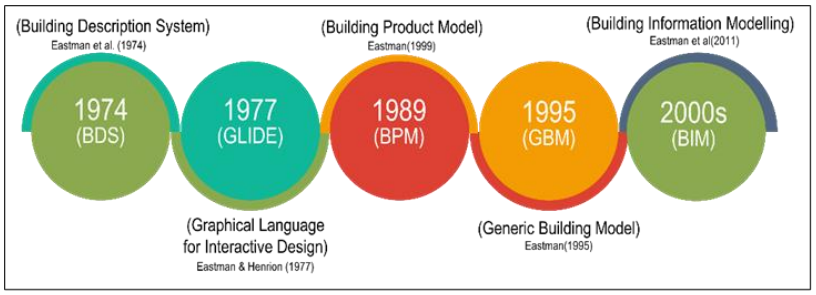

Figure 1: The Evolution of BIM
(Sinoh et al., 2020)

Since BIM was introduced to the AEC world, various scholars have come out with a definition of BIM.

Table 1
Possible definition of BIM from 2006-2020 adapted from (Ashworth, 2020)

Source	Definition
van Nederveen & Tolman, (1992)	"a model of information about a building that comprises complete and sufficient information to support all lifecycle processes and which can be interpreted directly by computer applications"
Lee et al. (2006)	"the 'process of generating and managing building information in an interoperable and reusable way"
Sabol (2006)	"representation of a building as an integrated database of coordinate, internally consistent and computable information on design and construction"

Penttilä (2006)	"is a methodology to manage the essential building design and project data in digital format throughout the building's lifecycle."
Succar (2009)	"An emerging technological and procedural shift within the Architecture, Engineering, Construction and Operations (AECO) industry."
Arayici & Aouad, (2010, p.3)	"The use of ICT technologies to streaming the building lifecycle processes to provide a safer and more productive environment for the occupants, to assert the least possible environmental impact from the existence and to be more operationally efficient for its owners throughout the building lifecycle"
Azhar (2011,242)	"a virtual process that encompasses all aspects, disciplines and systems of a facility within a single, virtual model, allowing all design team members (owner, architects, engineers, contractors, subcontractors and suppliers) to collaborate more accurately and efficiently than using traditional processes"
Golabachi et al (2013, p187)	"BIM is a value-creating process that involves the generation, management and exchange of knowledge of a facility forming a reliable basis for decision making throughout its life cycle from the conceptual design and construction phases through its operational life subsequent closure."
EU BIM Task Group (2017, p.4)	"a digital form of construction and assets operations. It combines technology, process improvements and digital information to improve client and project outcomes and asset operators radically."
Eastman et al (2011)	"a socio-technical system that ultimately involves broad process changes in design construction and facility management"
Jackson (2016)	"Observing BIM models are perceived as a 3D representation of a built asset. The model can be defined as a 'digital representation of physical and functional characteristics of a facility or assets."
BIM Dictionary (2019)	"a set of technologies processes and policies enable multiple stakeholders to collaboratively design, construct and operate a facility in a virtual space. As a term, BIM has grown tremendously over the years and is now the 'current expression of a digital innovation' across the construction industry."

ISO (2019)	"use of a shared digital representation of a built asset to facilitate design, construction and operation processes to form a reliable basis for the decision"
Autodesk (2020)	"a process that begins with creating an intelligent 3D model and enables document management, coordination and simulation during the entire lifecycle of a project (plan, design, build, operation and maintenance)."

BIM in Malaysia started in 2007 when the Public Work Department (PWD) published the BIM Standard Manual and Guidelines. The Construction Industry Development Board (CIDB) has recommended the mandatory use of Building Information Modelling (BIM) in specific private-sector projects by 2020. In addition, the Government has taken several measures to facilitate the adoption of BIM, including establishing the myBIM Centre as a one-stop reference, support, services and capacity-building Centre (Bernama, 2019).

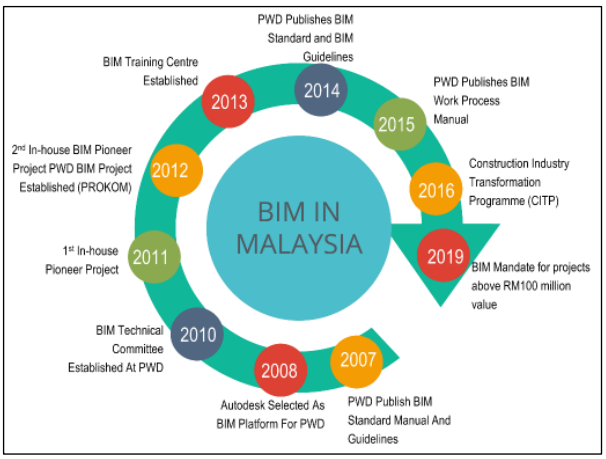

Figure 2:Timeline of Establishment of BIM in Malaysia
Adapted from (Sinoh et al., 2020)

Green Building

Over the past two decades, several rating tools have also appeared that aim to measure a building's environmental performance. As mentioned above, there are various GBATs in the market. It is a tool used to measure green buildings. National Green Technology Policy (NGTP) was released in 2009, promoting sustainable development by minimizing energy consumption growth through low carbon technology and conserving nature and natural resources (Chua & Oh, 2011). One research from China by Li et al (2019) listed the critical success factor for green building projects. The essential elements are communication and cooperation between project participants. The second place is effective project planning and control. The findings from Li et al (2019) will drive this research on integrating the BIM and green initiative.

Green Building Assessment in Malaysia was introduced in 2009, known as Green Building Index (GBI). Figure 3 shows the development of sustainability rating tools in Malaysia from 2009 until the latest development in the year 2016. Overall, there are ten green assessment tools in Malaysia to date. These developments are the initiative of both the Government and private sectors. The latest evolution of sustainable rating tools is from the Construction Industry Development Board (CIDB), and the Malaysian Carbon Reduction and Environmental Sustainability Tool (MyCrest). This tool aims to guide, assist, quantify, and reduce the built environment's impact in reducing carbon emissions and environmental impact while considering a more holistic life cycle view of the built environment. It also aims to integrate socio-economic considerations relating to the built environment and urban development (CIDB, 2020), as shown in Figure 3.

Figure 3: Development of Sustainability Rating Tools in Malaysia
(Hung & Fuad, 2018)

Green BIM

Integrating BIM and green initiatives or Green BIM has already started in China, the United Kingdom, Australia, Singapore and Malaysia. Research from Lu et al (2017); Olawumi & Chan (2019); Shukra & Zhou (2020); Wong & Zhou (2015); Wu & Issa (2015) is eye-opening to discover the potential of the integration between BIM and green initiatives to be implemented in Malaysia. BIM has been significantly impactful and beneficial (Eadie et al., 2013). Many authors define Green BIM. Wong & Zhou (2015) defined green BIM as "a model-based process of generating and managing coordinated and consistent building data during its project lifecycle that enhance building energy-efficiency performance and facilitate the accomplishment of established sustainability goals."

Analysis of Findings

Olawumi & Chan (2019) listed the key benefits are enhancing project efficiency and productivity, ensuring the real-time sustainable design and multi-design alternatives, facilitating the selection of sustainable materials and components, and reducing material wastage and the project's environmental impact.

Despite the benefits of Green BIM highlighted in the previous section, there are several challenges identified by other scholars. For instance, Othman et al (2021) highlighted a lack of awareness, slow adaptation and unavailability of a clear guideline to assist organizations and policymakers toward BIM implementation. The summary of the findings is shown in Table 2.

Table 2
Summarise of Findings on Benefits and Challenges of Green BIM

Author	Benefits of Green BIM	Challenges of Green BIM
(Olawumi & Chan, 2020) (Olawumi & Chan, 2019b)	• Enhancing project efficiency and productivity. • Ensuring real-time sustainable design and multi-design alternatives. • Facilitating the selection of sustainable materials and components • Reducing materials wastage • Project management impact	• Industry's resistance to change from traditional working practices. • Longer time in adapting to new technologies (steep learning curve) • Lack of understanding of the processes and workflows required for BIM and sustainability • Inadequate in-depth expertise and know-how to operate sustainability-related analysis software programs • Lack of initiative and hesitance on future investments • Organizational challenges, policy, and project strategy • Difficulty in assessing environmental parameters of building properties
(GhaffarianHoseini et al., 2017)	• Indoor air quality • Energy efficiency • Water efficiency • Materials • Management system	• Lack of awareness about benefits • Increase in upfront cost • Entrenched behaviour. • Lack of government incentive
(Lu et al., 2017)	• Facilitate data exchange and integration • Provide visualized building performance analysis and simulations • Assess design alternatives • Analyze various environmental impacts of the construction process • Contribute to waste reduction • Improve construction productivity and performance • Help to monitor the sustainability performance of buildings • Support the retrieving of energy and capital investments • Benefit waste management	• The weak interoperability among various green BIM applications • Lack of support for the construction and operation phases of green building gs • Lack of industry standards holistically covering the different application areas of green BIM and studies on the best practices of green BIM projects • Low industrial acceptance of green BIM applications • Insufficient accuracy of BIM-based prediction models

		• The lack of appropriate project delivery methods.
(Ismail et al., 2019)	• Effective communication and collaboration among team members • Reliable decision-making. • Improve team performance and productivity.	• The lack of experts amongst industry players has caused BIM applications not discipline-oriented • Software complexity issues. • Digital models develop limited information, and the restriction brings the manual assessment method to replace the BIM application. • The cost barrier
(Marzouk et al., 2021)		• Technological barrier • Financial barrier • Client influence • Human aspect barrier • The obstacle to changing the way people works
(Wong & Fan, 2013)	• Environmental Aspect • Social Aspect (Integrated project delivery (IPD)) • Economic aspect (Design optimization)	

Discussion of Findings & Conceptual Framework

It has been found that there are benefits and challenges in implementing Green BIM. Most identified both sides of green BIM. Based on Table 2, reducing material wastage is the highest number mentioned by scholars (Ghaffarianhoseini et al., 2017; Lu et al., 2017; Olawumi & Chan, 2020). It is undeniable when we can plan the type of material, quantity and quality at the early stage of the project. The simulation from the BIM software can predict and show the early result on when, how much it is needed, and how it looks like a final product indirectly help the client, designers and the contractor make the right decision regarding materials. Despite the significant benefits gained, some challenges of green BIM have been identified. Most scholars agree that the technological barrier is crucial in implementing green BIM. The acceptance rate between the construction participants is still low. The other identified challenges, for example, financial and human aspects, including lack of experts, could negatively impact the implementation of green BIM. The summaries of the result as shown in Figure 3. Further research on Green BIM should be conducted to determine the stakeholders' real problems in implementing green BIM. Since the discussion results are from the other countries, it is time to study the Malaysian side.

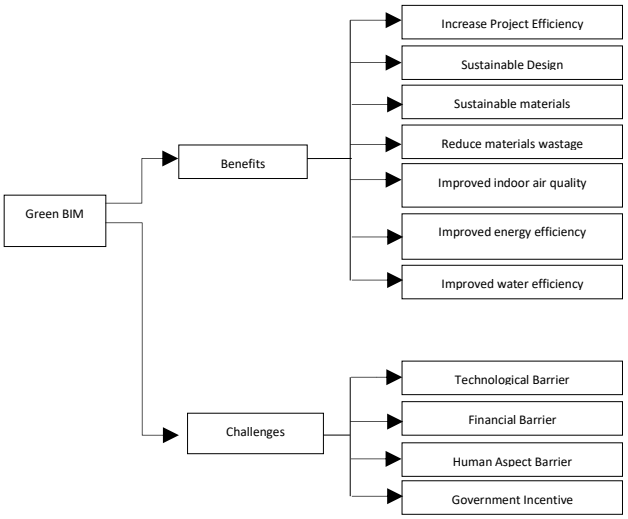

Figure 4: Conceptual Framework of the findings

Conclusion

It is a kickstart for the Malaysian construction industry to prepare inside out to integrate BIM and green initiatives. Since BIM and sustainability have received growing attention in academia and industry worldwide due to various initiatives and advantages. With the specific thrust on BIM adoption and sustainability efforts in CITP 2016-2020 and following with Construction 4.0 Strategic Plan 2021-2025, the two areas have become the national agenda. They are expected to grow in the Malaysian construction industry. The findings from the literature add to our understanding that BIM as an innovative tool has the opportunity to facilitate the idea of green BIM. It was discovered that BIM enables various sustainability analyses, specifically in water efficiency analysis, energy efficiency analysis, material and resources, waste management, indoor air quality, and project planning and management. The finding also aligned with the criteria stated in the GBAT, whereby the said criteria need to be fulfilled to get the certified green building.

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