BIM-based Approach for Green Buildings in Malaysia

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Abstract. The construction industry in Malaysia faces a number of complications in terms of managing project duration and budgeted cost. The recent technology trend has moved the industry towards adoption of Building Information modelling (BIM) as a mean to efficiently plan, design, build, manage and control projects. Since BIM is perceived as a holistic solution for integration of various project attributes, this research has hypothesised that additional objectives such as sustainability and green building design can simultaneously be achieved if appropriate BIM approach is implemented. The main scope of this research is to introduce a framework for integration of Malaysian Green Building Index (GBI) with existing Building Information Modelling (BIM) tools. The proposed GBI-BIM framework is made possible via the introduction of a set of supporting tools such as Revit Green Project Template (RGPT) and GBI Document Assessor that assist designers to automatically analyse and assess 56 out of 100 GBI points during the design stage.

1. Introduction
The current construction industry faces many complications, which can be weighed in terms of time, cost and quality of the final product. Complex projects carry risks of schedule delay and running over budget that require close monitoring and controlling. Malaysian construction industry struggles with these challenges as well [1, 2]. Building Information modelling (BIM) enables industries to efficiently plan, design, build, manage and control projects. The ease of integrated data sharing at preliminary stages of a project can prevent design and planning errors, activity clashes and duplications with minimal cost. As for the Malaysian construction industry, the demand for BIM application is high but the current implementation level is low; however, the roadmap projected for the construction industry anticipates broader adoption of BIM [3, 4]. On the other hand, Malaysia’s Green Building Index (GBI) as a sustainability rating tool has yet to be fully accepted by the construction industry. Majority of the construction companies and developers have low level of involvement in green buildings due lack of interest and unpreparedness [5].

The current industry challenges led the authors to select BIM as an appropriate tool for the construction industry to incorporate green practices into their current workflow as a holistic solution for sustainability along with many other construction obstacles. This paper is aimed to study the possibilities of integrating GBI framework with BIM framework. In 2007, Malaysian Public Works...
Department (PWD) recognized BIM as a suitable platform to reduce construction cost and design complications in planning phase by providing effective collaboration between construction players. Moreover, a number of pilot projects have been carried out as part of Malaysian government initiative in exposing government officers to BIM [6]. As announced by the Construction Industry Board Development Malaysia (CIDB), the Malaysian construction industry is moving towards broader adoption of BIM by 2020 [7]. Therefore, the outcome from this research is hoped to broaden the local application of BIM to cater for additional scopes such as green building and sustainability assessment.

2. Background
In order to implement, assess, monitor and control construction green practices, sustainability rating tools have been established. Among them are Building Research Establishment Environmental Assessment Method (BREEAM) in UK as well as Leadership in Energy and Environmental Design (LEED) in US. These rating systems differ from each other based on the assessment criteria and allocation of points; however, they were all developed with a common goal to save energy and resources and to minimize negative impacts on human and environment throughout the building’s lifecycle [8]. In Malaysia, GBI has been introduced to be the driving initiative for the construction industry to incorporate environment-friendly features that have positive overall impact in long term. Energy Efficiency (EE), Materials & Resources (MR), Water Efficiency (WE), Indoor Environment Quality (EQ), Sustainable Site Planning & Management (SM), Innovation (IN) are the main categories that must be evaluated for GBI certification process. Upon satisfactory based on design details and supportive documents relevant to each category, allocated points are granted at provisional stage followed by final verification stage. The accumulation of credit points leads to achieving GBI ratings such as platinum, gold, silver and certified.

Ayman, Alwan and McIntyre [9] stated the need for BIM application to overcome some of the barriers in delivering green buildings. In Malaysia particularly, risk of investment, higher investment cost, lack of technology, expertise, database and information, demonstration and technology assistance are some of the identified barriers in green building development reported by [10, 11]. Ayman, Alwan and McIntyre [9] anticipated that the direct impact of BIM utilisation on the sustainability barriers is reduction in time and cost due to better design coordination and effective decision making. As for the implementation of GBI framework, it requires responsible organisations that offer practical information and services, technical advice and carry out research to cater for future needs [12]. If BIM eventually matures to be the principal operational platform for the construction industry in Malaysia, the likeliness of these challenges and barriers diminishing can increase drastically. Therefore, this can be the driving force for linking GBI with BIM in order to overcome the current challenges. As BIM technology is relatively new in Malaysia, not many academic publications have been dedicated to the technical aspects of BIM integration with GBI. Therefore, this research shall identify an integrated approach during the design stage that leverages from BIM application for automatic evaluation of green buildings in accordance with the GBI assessment categories.

3. Literature Review
The most noticeable feature of a BIM model is the digital 3-dimensional presentation of the building information. By having a closer look into the BIM models, various types of information can be obtained such as geographic information, quantities, and properties of each element [13]. Number of researchers have investigated the potential for automation of green building rating systems through BIM application. Azhar, Brown and Sattineni [14] established the possibility to perform sustainability assessment using various available software such as Autodesk Revit™ and IES Virtual Environment for 38 LEED points. Barnes and Castro-Lacouture [15] stated that 13 credits and 1 prerequisite can be directly evaluated and documented by using Autodesk Revit for the LEED rating system.

There are number of software and tools available in the market that are beneficial for green assessment. Lu, Wu, Chang and Li [16] identified Autodesk Revit and Green Building Studio (GBS) amongst the prevalent BIM tools utilised by green BIM researchers. For instance, Autodesk® Green
Building Studio is capable of building performance simulation focusing on LEED assessment for energy performance [17]. Since GBI assessment criteria and documentation required for submission are not entirely similar to LEED assessment, the default functionality from the available tools do not fully correspond with the assessment requirements. Solla, Ismail and Yunus [18] investigated the current trend in green BIM industry in order to address the potential and need for integration of BIM with GBI. Only 1 out of 6 GBI assessment category, Energy Efficiency (EE), has ever been attempted to be integrated with BIM. Lim, Sediadi, Shahsavari and Azli [19] proposed a methodology through which buildings can be evaluated via Building Energy Information Tool (BEIT), Autodesk Revit and Excel spreadsheet in partial fulfilment for GBI assessment at the design stage. Although BEIT is capable of producing rapid outputs, it still requires the user to manually provide inputs such as general project information, building envelope properties, lighting power, plug load and cost for both the baseline and the proposed building [20]. This issue leaves a gap between the actual building design and the analysis related to it, if there are any input mistakes [21].

4. Methodology
4.1. Research Framework
A research framework is presented covering three main factors identified for this paper (Standard and Policy, Tools and Processes as well as Green BIM Lifecycle) that have influence on the GBI-BIM assessment framework (figure 1). Each domain was established upon conducting a preliminary study that are discussed briefly in the following section.

![Figure 1. Research Framework](image)

4.1.1. Standard, Guideline and Policy. In terms of green building standards, GBI guidelines intended for assessment criteria and the documentation required for submission are studied. The BIM industry guideline introduced by the CIDB myBIM is taken into consideration focusing on adoption and execution of BIM [22]. Currently there is no BIM policy enforced by the Malaysian government [23].

4.1.2. Tools and Processes. The focus of this research is to introduce an integrated process for optimization of existing technology for green building design and assessment. Figure 2 illustrates the technical methodology whereby each GBI assessment category is studied independently in order to identify appropriate inputs and parameters to be processed via Revit as a selected BIM tool. As a result of the proposed methodology, Revit Green Project Template (RGPT) is produced to aid BIM users in documentation and assessment of green buildings. Due to functionality limitations of the selected BIM
tool, an extended process is developed to automatically assess and rate buildings based on the documents produced by the RGPT. The extended process is referred to as GBI Document Assessor.

4.1.3. Green BIM Lifecycle. This cycle is a result of aligning a typical building lifecycle in BIM environment with GBI assessment process. The GBI certification process involves registration, design stage assessment, verification assessment and certification renewal. It can be deduced from figure 3 that the green building certification has a recurring cycle similar to BIM building lifecycle. Therefore, utilisation of BIM for green building assessment can take place at various stages of a project lifecycle; for that reason, different Level Of Development (LOD) for the BIM model is required depending on each assessment stage. The focus of the current research is to identify the green-BIM information necessary for the design stage assessment.

5. Result and Discussion
The BIM tool was explored to investigate the feasibility of linking and processing parametric building information related to each GBI subcategory. As a result, total of 56 out of 100 GBI points (equivalent to 23 out of 51 subcategories) were identified to be automatically assessed with the support of RGPT.
and GBI Document Assessor during the design stage. RGPT as a customised template format (.rte) automatically gathers and calculates relevant project information aligned with GBI assessment. The GBI Document Assessor as a simple XLS file is created to automatically analyse the green building information produced by RGPT and subsequently allocate points. The application process involves the Revit users to launch RGPT and create/link a typical BIM model with sufficient details (LOD 300) and further validate the parametric information presented in schedules (figure 4). Upon satisfaction, the RGPT report is exported as a text report to serve as the input to GBI Document Assessor. The GBI Document Assessor automatically allocates score points and subsequently reports the building rating. Figure 5 is a sample result for GBI Materials and Resources category demonstrating how parametric information from the BIM model is gathered and tabulated automatically via RGPT and further evaluated by GBI Document Assessor.

The development of a template file is important for minimizing any duplication of efforts for future projects. Furthermore, development of RGPT is going to be the result of optimization of existing BIM tool (Revit) which is hoped to reduce the need for developing new green assessment tools. Based on the preliminary evaluation conducted, the calculations and tabulations automated within RGPT is suitable as supporting documents to be submitted for GBI assessment.

The following are some of challenges reported by Han, Motamedi, Yabuki and Fukuda [24] that needs to be tackled when a new Green BIM approach is addressed: (A) The BIM model should deposit all of the data related to green building rating standard; (B) Green data extraction for the assessment must to be automated; (C) All the assessment credits must be covered in the extraction process. The methodology in this paper has proposed for allocation of custom parameters where default Revit parameters are insufficient to address GBI related data. The automation of green data extraction is established through Revit schedules that has been set as a template (RGPT) whereby the extraction and calculation module is embedded with the BIM tool. Since all the inputs for the calculation is automatically linked to the BIM model, input errors will be minimised. As mentioned in the technical methodology, the framework is focused on addressing parameters and processes associated with every GBI assessment category individually.

As BIM implementation matures, the construction and operation phase become more informative and accessible at earlier phases of the lifecycle [25]. This added advantage through Green BIM application is anticipated to be aligned with similar principle whereby planning and designing green buildings gains more accuracy with higher level of certainty based on the quality and quantity of the green-related information available at the earlier stages of a project. Correspondingly, the ultimate contribution of BIM to sustainable building design is projected through two main perspectives of Integrated Project Delivery (IPD) and design optimization [26]. With the application process proposed, the designer is able to optimise the BIM model while having instant access to green related information upon any changes to the design.

Figure 4. Application Process
Figure 5. Automated GBI assessment via RGPT and GBI Document Assessor
6. Conclusion
The application of BIM for the construction industry is broad; however, sustainability was found to be an emerging aspect of BIM that has been evaluated by many researchers worldwide. Based on the literature review conducted, BIM can support green buildings during planning, design, construction, operation and maintenance stage. GBI as the Malaysian sustainability rating tool needs to reach the maximum potential in terms of industry acceptance and practice. Therefore, this paper proposed that BIM can be incorporated with GBI if suitable approach and tools are introduced into their workflow. The early stages of the project lifecycle signify the expediency of implementing BIM since the early decisions majorly contribute to the long-term performance and maintenance of a building. Utilizing BIM tools during the design stage provides a process to apply changes and analyse the results iteratively. BIM as a tool is supportive to the designers and owners to achieve desired GBI points by enabling them making constructive decisions regarding the incurring costs and resources associated with green building design. The primary attempt of this research is to utilise Autodesk Revit to develop Revit Green Project Template (RGPT) for addressing additional parameters associated with GBI. Lastly the GBI Document Assessor is added to the application process for automatic allocation of GBI points based on the report produced via RGPT. These supporting tools help users to save time in documentation preparation and assessment of green buildings. Furthermore, development of RGPT is going to be the result of optimization of existing BIM tool (Revit) which is hoped to reduce the need for developing new green assessment tools.

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