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A Study on the Feasibility of Retrofitting Tunku Tun Aminah Library Towards Green Building

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Abstract: Green buildings are designed to enhance energy efficiency and resource management. Whereas, retrofit is the method of transforming and modifying systems and technologies in an existing building to combat environmental depreciation. Hence, retrofitting existing buildings that meet green building requirements enhances the sustainable environment. In Malaysia, the increment of energy consumption in institutional buildings is attributable to the university's activities and population. Therefore, the purpose of this study is to analyze whether the exiting UTHM's library building applied with the concept of green building and explore the feasibility of retrofitting UTHM building that responds to sustainable green building standards. The approach of this study was developed through a literature review and quantitative research using a questionnaire approach. The data gathered was then analysed using SPSS version 26 to obtain the mean index score. The results showed that the UTHM's library building has fulfilled only two of the GBI criteria which are Energy Efficiency and Indoor Environmental Quality with the mean index scored above 3.5. Thus, all sub-elements in the green building requirement with mean index lower than 3.5 should be considered to retrofit in the future. To conclude, the campus management could consider immediate measure to comply with green building standards to optimize energy consumption, which can be accomplished through appropriate retrofitting of existing structures.

Keywords: Green Building, Retrofitting, Library Building

1. Introduction

Malaysia is a developing country where energy usage has become extremely crucial to economic growth, resulting in significant greenhouse gas emissions and natural resource degradation. Green buildings emit 50% less greenhouse gas than conventional buildings [1]. As a result, to address environmental problems and energy demands caused by greenhouse gases, Malaysia's government has implemented a sustainable development strategy that known as a green building index [2]. Green building strategy also can mitigate environmental consequences, climate-related issues, operating costs, and reduce resource consumption.

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Existing university buildings are reported to be the greatest energy consumers when compared to new university buildings that comply with the Green Building Index, GBI. According to Latif et al. [3], 38 percent of the electricity generated throughout the country is used to power university facilities. This issue piques the Ministry of Higher Education's (MOHE) interest, causing them to be concerned about sustainable building, particularly in university buildings and facilities [3]. As a result, to construct addition green buildings in upcoming institutional projects, existing buildings can be retrofitted where it is more cost-effective [4]. As to meet the requirements of the green building characteristics, GBI is a rating tool to evaluate all requirements for retrofitting the existing building [4]. Green Building Index, GBI-NREB is an assessment tool with a special requirement that is used to enhance green buildings construction in Malaysia [5].

Technically, Tunku Tun Aminah Library (TTAL) building in the UTHM campus was designed with a modern and sustainable concept that incorporates "Energy Efficiency Design" strategies to achieve maximum energy efficiency. However, the library building has not received a certificate from any organization that recognizing it as a green building. Therefore, this paper is intended to analyze whether the UTHM library building has yet fulfilled all of the green building elements and propose potential retrofitting that responds to sustainable green building standards.

2. Green Building and Retrofitting

It is critical to adopt the green buildings concept as reducing greenhouse gas emissions which will harm the environment and building users. This led to history in Rio de Janeiro in 1992, when the concept of green building was officially proposed to meet the needs of users without jeopardizing the ability to conserve energy and minimize environmental issues [6]. Green buildings provide satisfaction and an effective working environment in addition to other benefits such as lower operational costs, reduced energy consumption, a healthy working environment, and reduced waste production when compared to conventional construction [7]. However, the concept of green building is still a fresh technology in construction because it appears difficult to develop a green building that guarantees higher quality, comfort, and cost-effectiveness in residential buildings [8].

The green building characteristic is important to ensure that the functionality as a comfortable, cost-effective, and energy-consuming buildings is truly implemented into the buildings. More than 60 countries developed various evaluation tools and techniques to analyze the performance of the building industry in environmental problems. Green Building Index, GBI, was established in Malaysia as an assessment tool to evaluate green buildings in Malaysia. The mains elements in GBI assessment tools include energy efficiency, indoor environment quality, sustainable site planning and management, material and resources, water efficiency and innovation [9]. With the presence of GBI, gold, platinum, and silver certificates can be awarded to green buildings that outperform in terms of operational performance and pass the GBI value to encourage the construction industry to implement green building effectively [10].

Nevertheless, this green building concept has only been around for a few years. Several of the structures, such as historical buildings, were constructed decades before the green building policy was implemented, and several of the new construction did not adhere to the green building approach and, as a result, did not meet the requirements of the approach [11]. Hence, the concept of retrofitting was eventually introduced. Retrofitting is defined as the method of transforming and modifying systems and technologies in the existing building to combat environmental depreciation [12]. Modifying an existing building can be more economically efficient than creating a new green structure. Moreover, retrofitting helps to eliminate associated waste and conserve energy from new building construction [13]. Apart from that, retrofitting is significantly low cost as it delivered better financial results and lower energy, operating and lifespans expenses. In contrast to new building construction, retrofitting can be completed in a short period [14]. To ensure the effectiveness of retrofitting, several strategies were introduced to ease the process of retrofitting. This covers the time duration of the installation, integrated planning, design, and documentation, budgeting for the refit, including sustainable development, and rehabilitation of the current building system [11]. Therefore, to properly solve the problem of maintaining energy usage, the existing institutional buildings has to be retrofitted.

3. Methodology

The research methodology described the methods and approaches used to accomplish the study's objectives. The method of convenience sampling was used to choose the library users as respondents and a purposive sampling was employed to select experts in Pusat Pembangunan dan Penyenggaraan (PPH). The literature review is performed to obtain relevant information regarding green building criteria and the potential retrofitting of existing buildings. While, quantitative research was used to evaluate the factors that must be considered on the concept of green building elements and potential retrofitting of the existing building. The method used to achieve the objectives of this study consist of three phases. The first phase was identifying the research title, the background study, the problem statement, the objectives and the scope of the study. The second phase was to study the concept of green building and the potential retrofitting of UTHM's library building to meet sustainable green building standards. The instrument used for this study was a questionnaire survey. The questionnaire survey consisted of three parts: A, B, and C. Part A detailed the respondent's age, career, and professional experience. Respondents were needed to respond by selecting the appropriate answer. Part B contains 26 questions based on respondents' opinions and observations of the concept of green buildings that have been implemented in the UTHM library. As for Part C, 18 questions involve asking the suggestion from respondents pertaining to the potential retrofitting that can be applied in the future for the existing building to meet the GBI criteria and sustainable building. Both Part B and Part C were closed-ended questions whereby the respondents required to rate the questions using the 5-point Likert scales: "strongly disagree", "disagree", "neutral", "agree", "strongly agree". The questionnaire survey was distributed to the engineers, architects, technicians, library officers, and library users who worked at TTAL and PPH buildings. A total 70 respondents participated in this study. Finally, the third phase were data analysis, discussion, conclusion and recommendation. The surveyed data were examined through average index analysis (AIA) and reliability (Cronbach Alpha) in SPSS version 26 software. Lastly, the findings were discussed to achieve the objectives of the research where a range value greater than 3.5 indicated that the findings were significant and appropriate for the study.

4. Results and Discussion

4.1 Energy efficiency criteria

Figure 1 depicts the average index of energy efficiency. Based on the results, the most efficient sub-elements used in the TTAL building is a sufficient number of lighting fixtures placed, with a mean index of 4.14. Based on the user observations, the light bulbs were mostly installed in the study area, which requires adequate lighting. While the building with the lowest mean index of energy efficiency is 3.61, it is equipped with a solar energy system such as a photovoltaic panel. However, because the mean is greater than 3.50, this result is still considered significant. According to the expert respondents, this building has recently installed photovoltaic panels on its rooftop; however, many users and the UTHM community are unaware of the existence of this new solar energy system. Overall, all sub-elements of energy efficiency have exceeded the 3.5 mean indexes which indicates that this element has been fulfilled.

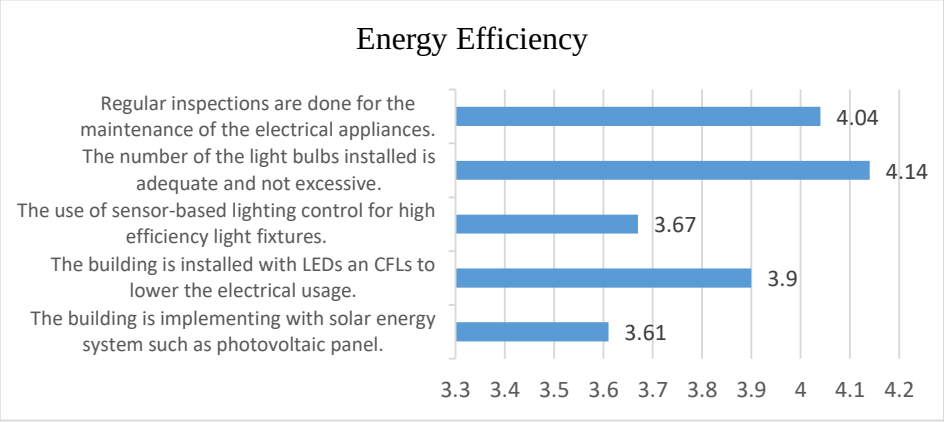

Figure 1: Mean index of Energy

4.2 Indoor environmental quality criteria

Based on Figure 2 below, it indicates that all of the sub-elements of indoor environmental quality scored higher than the 3.5 mean indexes, implying that the elements of indoor environmental quality are incorporated in the TTAL buildings and the respondents are aware of it. The highest value of the mean index, as shown in Figure 2, is 4.56. This indicates that most of respondents agreed that implementing smoking regulations could reduce users' exposure to cigarette smoke. While, the least preferred option by respondents is installing a dedicated exhaust as a balance ventilation system with mean index score of 3.61. This is because the exhaust fan is only installed in the toilet, and the rest of the area is covered with air conditioning to balance the ventilation system.

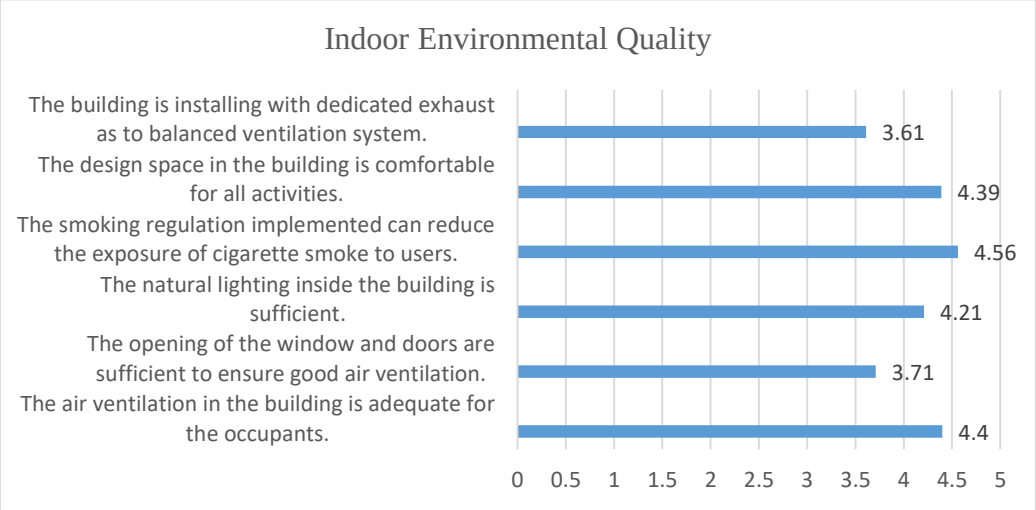

Figure 2: Mean index of Indoor Environmental Quality

4.3 Site planning and management criteria

Figure 3 depicts the mean index for long-term site planning and management. Most respondents do not agree that the building has a green roofing system because the mean index is 2.70. This indicates that green roofing systems have not yet been installed in this building. This is because green roofs are heavier and require more structural support to be implemented, it will increase the weight load. While the highest score is 4.3 for the parking location is suitable for the location of the building itself. This is because the university's administration has provided nearby parking spaces around the library. The other sub-elements of sustainable site planning and management, on the other hand, scored more than the 3.5 mean indexes, indicating that it is acceptable.

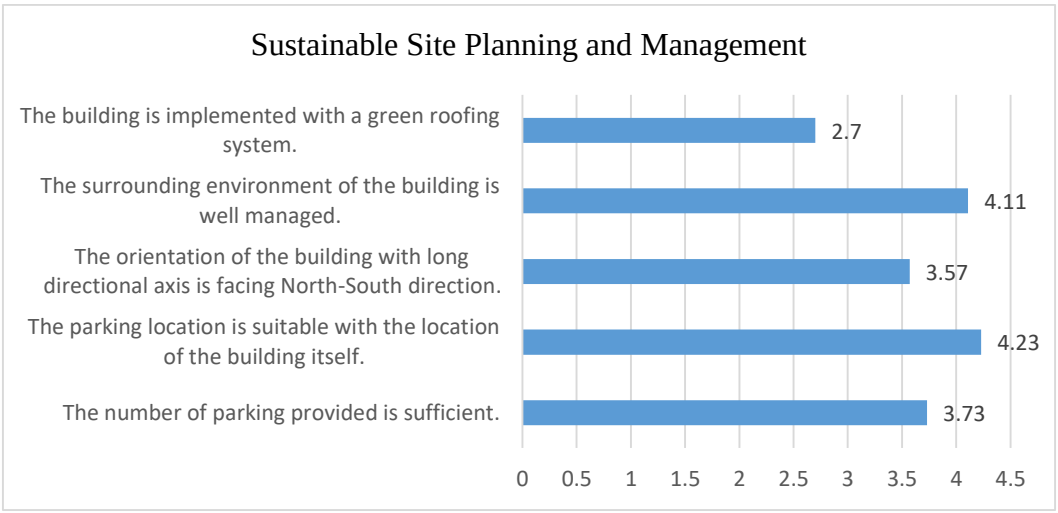

Figure 3: Mean Index of Sustainable Site Planning and Management

4.4 Material and resources criteria

According to Figure 4, only one sub-element of material and resources scored more than the 3.5 mean index, indicating that a recycling storage area is available at the library building. The mean index for the other three sub-elements of material and resources is less than 3.5, indicating that none of these elements has yet met the requirement for this element. This is because, even though the library management provided recycled material storage, the capacity of the storage appears insufficient. Thus, it can be concluded that the material and resources element has been partially fulfilled. As a result, all sub-elements that scored less than 3.5 of the mean indexes should be taken for future retrofitting.

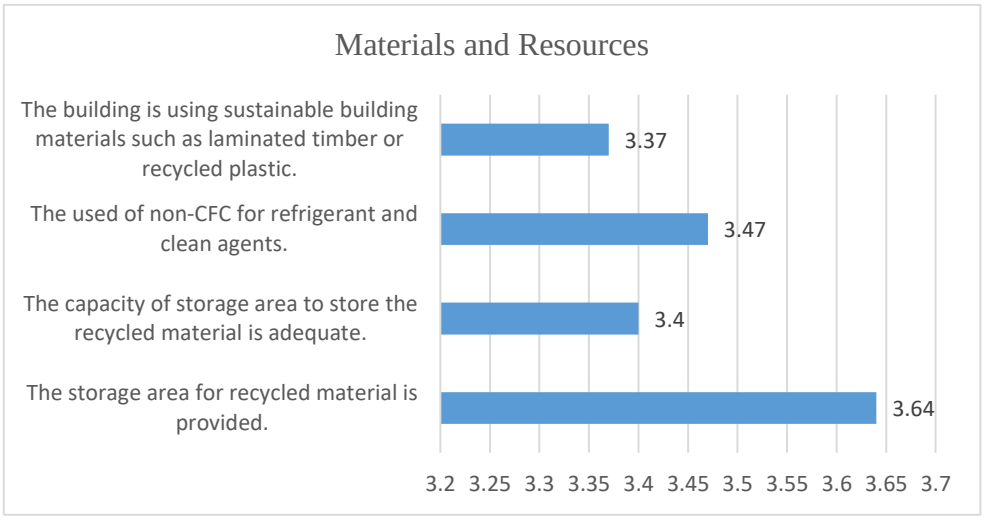

Figure 4: Mean Index of Materials and Resources

4.5 Water efficiency criteria

The highest mean index value shown in Figure 5 is 3.99 which represent that regular maintenance is performed to monitor any water leakage in the building. The other two sub-elements of water efficiency which are the building are using water recycling system like treated greywater and the building is implementing with rainwater harvesting system did not meet the GBI requirements since their mean index scored lower than 3.5. This is because by installing a rainwater harvesting system and a water recycling system using treated greywater water in the library building would be impractical due to the high initial cost of construction, the need for regular maintenance, cleaning, and repairing, storage capacity limitations, and risks associated with inadequate greywater reuse. Therefore, the data showed that this element has partially fulfilled since several of the sub-elements of water efficiency scored lower than 3.5 mean index and potential retrofitting should be explored.

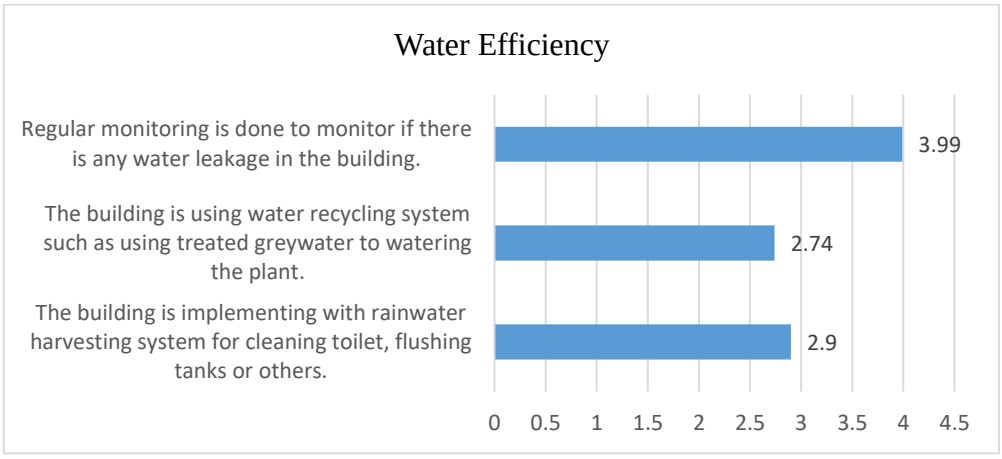

Figure 5: Mean Index of Water Efficiency

4.6 Innovation criteria

Figure 6 depicts the final element of GBI, which is innovation. According to the mean index results, the highest mean index value is 4.03, with the majority of respondents agreeing that the building's design concept is toward sustainable construction. This is because some green building elements, such as solar panels, natural lighting inside the building, recycling materials, and others, have been implemented in the TTAL building. This outcome is followed by the second highest mean index value, which is the environmentally friendly building components, with 3.59. Whereas the building uses an industrialized building system indicates the lowest mean index for this element is 3.21. Hence, it is reasonable to conclude that the building has not yet been equipped with an industrialized building system. Thus, all of the sub-elements with an average index value lower than 3.5 should be explored for potential retrofitting.

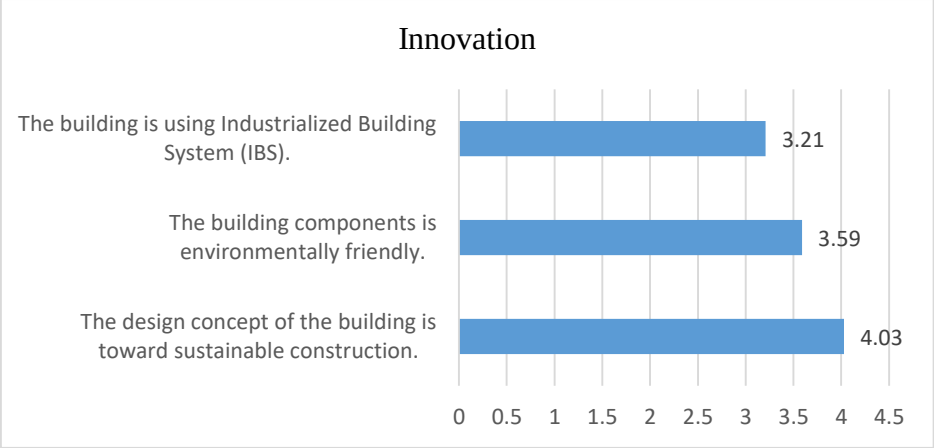

Figure 6: Mean Index of Innovation

4.7 The potential retrofitting of UTHM library building

According to the results shown in Figure 7 below, it shows that all of the items that potentially can be implemented in retrofitting TTAL building to achieve green building standard score greater than 3.5 average index value, except one item which is increasing the number of windows opening in the building, which scored 3.46 mean index. Hence, the other items that passed the 3.5 mean indexes are acceptable for later implementation. The first criteria that can be retrofit according to GBI are energy efficiency. The relevant retrofit for energy efficiency includes installation of solar thermal energy, upgrades the traditional lighting systems, providing flexible light control systems such as motion detection sensors and providing sub-metering electricity for monitoring. Based on the sub-element in energy efficiency, the highest-ranked item is to provide flexible lighting control systems such as motion detection sensors with a mean index of 4.41. This is because most of the respondents agreed that replacing traditional lighting systems with motion sensor lights is suitable green feature and this system will reduce electricity consumption while also lowering carbon emissions and saving money on utility bills. The other sub-elements of energy efficiency are also suitable to be implemented in the future because the items score above 3.5.

The second GBI criteria that has potential to be retrofit is indoor environmental quality. The retrofit ideas that can be done using indoor environment quality are using low volatile organic compound (VOC) emission materials, installation of exhaust fan, providing CO2 sensors to monitor air quality and increasing the number of windows opening in the building. Among the listed sub-element of indoor environmental quality, providing CO2 sensor to monitor air quality is the most preferable methods chosen by the respondent with the mean index of 4.29. While the least agreeable of a retrofit from

respondents are increasing the number of windows opening in the building with a 3.46 mean index. This is because, the building has air conditioning systems, increasing the number of windows opening in the library building is not required. Thus, this item is not relevant to be implemented in the building. The next criteria are Sustainable Site Planning and Management. It is suggested that green roofing be installed for the existing building, with the average index of this item being 3.60. This is because installing green roofing with limited vegetation can reduce the heat island effect, particularly during the day, as well as encourage the biodiversity of habitat flora and fauna.

In the criteria of material and resources, the feasibility retrofitting that can be employed in the UTHM library building are using green products or materials in the building, recycling and waste management practices and introducing green purchasing policies. According to the results, recycling and waste management practices are the most recommended by respondents in the material and resources criteria, with a mean index value of 4.29. This is also the way to collect and analyze information on the types and amounts of waste generated by the building and figure it out the ways to reduce the waste. The results were followed by the use of green products or materials and green purchasing policies with the mean index of 4.21 and 3.97 respectively. Meanwhile according to water efficiency elements, providing half flush system in the toilet, installation of rain harvesting system, and provides a water tab with a sensor in washroom can be the significant ideas for retrofitting. According to these criteria, the most preferred retrofitting by respondents is installing a water tap with a sensor in the restroom, which has a 4.17 mean index value. The reason is the sensor taps provide water savings, allowing users to conserve water while also becoming more hygienic and energy efficient.

The final GBI criteria is innovation. The sub-element that can be implemented for retrofitting includes use of renewable energy, installation of self-cleaning glass façade and promote innovative and environmental practices. The largest index value in these criteria is achieved by promoting innovative and environmental initiatives, with a mean index value of 4.4. All in all, based on the previously calculated average AIA value, the most potential retrofitting that can be done in this existing building that responds to green building standards is by providing flexible lighting control systems such as motion detection in order to reduce energy consumption. Thus, these potential retrofitting seems can reduce the energy consumption, reduce the carbon emissions, enhances workplace conditions, encourages the use of sustainable energy and minimize the expenditure of water consumed in the UTHM library building.

5. Conclusion

In this paper, the concept of green buildings that have been applied to the UTHM's library building have been evaluated. The result shows that the buildings have fulfilled two out of six elements of green building which are energy efficiency and indoor environmental quality. While, the other green elements have been partially achieved. All of the sub-elements that scored less than 3.5 on the mean index should be considered to be taken as future retrofitting. This study also identified that the most significant methods that can be suggested to retrofit the UTHM library building was by providing flexible lighting control system such as motion detection lighting sensor. With this system, it helps to minimize the energy consumption and saving money on utility bills. Other than that, the feasibility of retrofitting that can be applied were by providing CO2 sensors to monitor the quality of air, installing the green roofing at the top of building, installing water tap with sensor in the washroom and promoting innovative and environmental initiatives to the building management. In hopes, these potentials retrofit will helps solving environmental problems and improving the green building elements in the existing buildings.

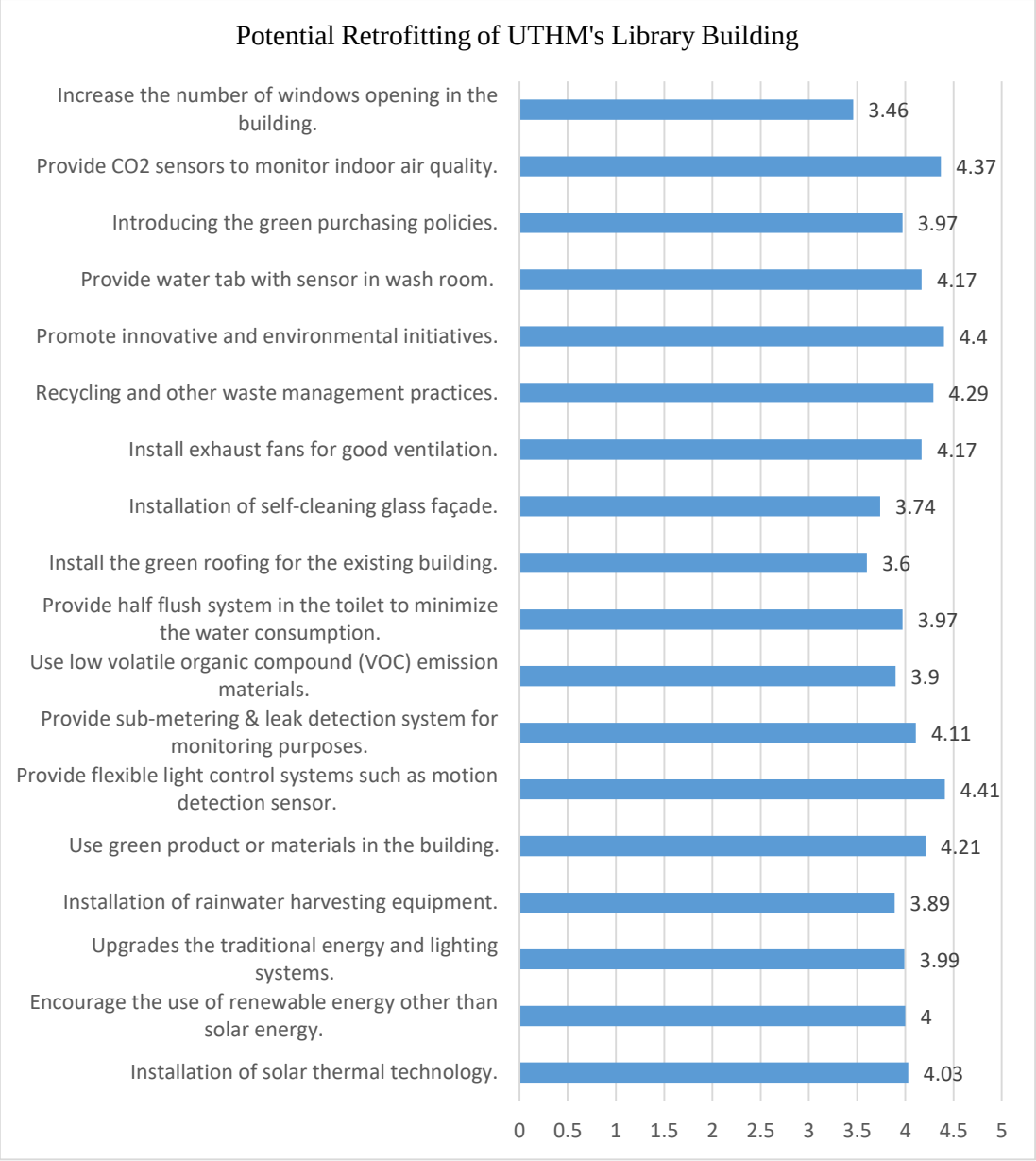

Figure 7: Potential of Retrofitting UTHM's Library building

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