*International Journal of Business and Technology Management*
*e-ISSN: 2682-7646 | Vol. 5, No. S3,59-67, 2023*
*http://myjms.mohe.gov.my/index.php/ijbtm*
*SPECIAL ISSUE: International Virtual Go Green 2023 (i-VGG 2023)*

# Challenges in Solar Maintenance Strategies: Analysing Determinant Factors for GBI Buildings in Malaysia

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Received: 9 July 2023 | Accepted: 10 August 2023 | Published: 1 October 2023

DOI: https://doi.org/10.55057/ijbtm.2023.5.S3.7

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**Abstract:** *Green and sustainable construction, sometimes referred to as green buildings, plays a crucial role in guaranteeing the advancement of society that aligns with the requirements and aspirations of future generations. The objective of this study is to ascertain the essential elements of maintenance management methods for solar energy applications in workplaces that have received certification under the Malaysian Green Building Index (GBI). The research aims to aid developers and building owners in the strategic planning of future projects. To accomplish this, the study pursued three primary objectives: (1) conducting an analysis of the current maintenance management techniques employed for solar energy utilization in GBI offices located in Malaysia; (2) evaluating the importance of key aspects that influence these strategies, and (3) defining the strategies that are most critical in nature. The research methodology employed a quantitative strategy, which involved conducting a comprehensive literature analysis and administering a questionnaire survey. Microsoft Excel 365 facilitated the data analysis process by providing a platform for organizing and evaluating replies in a manner that allows for the ranking of their relative value. The research findings will be juxtaposed with the current body of literature to enhance knowledge and understanding within the subject. The study utilized the Relative Importance Index (RII) methodology to prioritize a comprehensive set of essential factors associated with maintenance management in green buildings within the context of Malaysia. This study employs the RII technique to identify and prioritize the issues that have the potential to impede the effectiveness of maintenance management systems. The findings of this study offer significant contributions to the understanding of maintenance protocols for solar energy systems in workplaces that have received GBI certification. These insights can serve as a valuable resource for future developers and building owners, aiding them in the development of efficient strategies. The assurance of sustainable and effective deployment of solar energy in Malaysia's built environment, leading to a greener and more sustainable outcome, relies on comprehending the key aspects that significantly influence maintenance management.*

**Keywords**: Green building, maintenance management, Relative Importance Index

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## 1. Introduction

The field of Facility Management (FM) holds significant importance and exhibits a dynamic nature within the built environment. It encompasses a diverse set of tasks aimed at ensuring the efficient administration, repair, enhancement, and adaptation of an organization's facilities and infrastructure. According to Atkin and Brooks (2000), Rock et al. (2019), Jensen et al. (2023), and reputable international Facilities Management (FM) organizations such as BIFM, BFM, and IFMA, there is consensus that FM serves as an integrated strategy that plays a vital role in establishing an environment that effectively aligns with an organization's primary objectives, thereby facilitating the achievement of its goals. The importance of Facility Management (FM) specialists in ensuring the upkeep and optimal functioning of buildings has been underscored by scholars such as Zuriati (2005), El Ammari and Hammad (2019), and Patacas et al. (2020). The growth of ambitious megaprojects in Malaysia is anticipated to result in a significant increase in the need for facilities management services. This trend highlights the extensive range and significance of facilities management across diverse industries.

Within the extensive range of facilities management tasks, energy management has emerged as a crucial area of concentration. The optimization of energy use and the development of innovative resource conservation methods are of utmost importance to facility managers, who prioritize energy efficiency. The adoption of green building standards has emerged as a fundamental aspect of contemporary construction practices, as commercial buildings strive to obtain validation from reputable green ecolabeling organizations to verify their commitment to environmental sustainability (Isa et al., 2013).

Given the current problems and opportunities, the objective of this study is to investigate the complex terrain of maintenance management, specifically focusing on the maintenance methods for solar energy applications in workplaces certified under the Malaysian Green Building Index (GBI). This research aims to provide significant insights for developers and building owners regarding the primary drivers that impede maintenance management. The focus is on planning and executing sustainable and efficient solar energy systems. This study seeks to contribute to the improvement of the built environment in Malaysia and beyond by highlighting the significant role played by Facilities Management (FM) specialists in maintaining an environment that is conducive and environmentally friendly.

Malaysia has the most potential to use solar power as a renewable energy source. So, the average amount of solar radiation that Malaysia receives is 4500 kWh/m2/day. Kota Kinabalu receives the most radiation at 1900 kWh/m2, while Bayan Lepas and Georgetown receive the least at 1890 kWh/m2 and 1785 kWh/day, respectively (Aziz, 2016). On average, a square meter of Malaysian soil receives between 4 and 5 kilowatt-hours of sunlight per year (Ahmad et al., 2020).

FM's focus on broad policies instead of sustainability is one of the biggest problems in coming up with a comprehensive, consistent, and sustainable FM policy in Malaysia. Few Malaysians have had direct experience with solar energy technologies, which makes people less excited about using them more (Ahmad, 2014). Energy use is one of the most expensive parts of running a business, so it's important to keep track of it. Therefore, the FM team's annual budget should include steps to ensure long-term profitability. Green office buildings are expected to use less energy, and this can be improved by figuring out what factors affect the approach. So, strategies and plans for using solar energy can be put into action effectively.

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## 2. Literature Review

### 2.1 Maintenance in Facilities Management

Malaysia exhibits significant potential for harnessing solar power as a viable and sustainable source of renewable energy. The mean solar radiation received in Malaysia is approximately 4500 kilowatt-hours per square meter per day. According to Aziz (2016), Kota Kinabalu receives the highest amount of radiation at 1900 kWh/m2, while Bayan Lepas and Georgetown receive comparatively lower amounts at 1890 kWh/m2 and 1785 kWh/day, respectively. According to Ahmad et al. (2020), the annual solar irradiance received by a square meter of Malaysian soil ranges from 4 to 5 kilowatt-hours.One of the primary challenges in formulating a comprehensive, consistent, and sustainable Facility Management (FM) policy in Malaysia stems from the predominant emphasis on broad policies rather than sustainability. According to Ahmad (2014), a limited number of Malaysians possess firsthand familiarity with solar energy technology, resulting in reduced enthusiasm towards its adoption. The management of energy use is a significant financial burden in business operations, thus necessitating diligent monitoring and oversight. The annual budget of the FM team should incorporate measures to ensure long-term profitability. It is anticipated that green office buildings will exhibit reduced energy consumption, and this outcome can be enhanced by identifying and analyzing the components that influence the approach. The implementation of strategies and plans for the utilization of solar energy can be executed very efficiently.


**Figure 1: The SFM Model (Jughans, 2011)**

**Table 1: Dimension and target of sustainability**

| Dimensions of sustainability | Target |
|---|---|
| **Environment** | reduction of resources<br>The use of recyclable building materials; taking into account the reusability of used materials; cutting back on energy use and turning to renewable energy sources.<br>Reduced space requirements and soil sealing; preservation of building maintenance and demolition capabilities.<br>stopping the use of materials that produce excessive amounts of pollution |
| **Social** | supply of adequate buildings for work and life<br>compliance with health, safety and security requirements |
| **Economy** | building space optimization for a most efficient usage<br>optimization of building life-cycle costs<br>facilitating the most efficient management methods. |

## 2.2 Application of Solar Energy in Green Building

### 2.2.1 PV Technologies

It was in the 1980s that Malaysia began using photovoltaic technology to power rural regions for electrification and telecommunications, communication towers, and consumer products. The solar power sector in Malaysia comprises two submarkets: stand-alone PV power systems and on-grid PV power systems. Off-grid PV power systems can be further categorized into two types: domestic and non-domestic. Domestic PV power systems are connected to the grid, while non-domestic PV power systems are those that are not connected to the grid (Saidur, 2009).In 2006, there were a total of 20 Building Integrated Photovoltaic (BIPV) installations, resulting in a total installed capacity of 486 kWp. Among them, the Enterprise Four Building in Technology Park Malaysia holds the largest installed capacity of 361.9 kWp, accounting for about 74.5 percent of the total installed BIPV capacity. The successful implementation of such a large-scale photovoltaic (PV) project demonstrates Malaysia's capability in this field (Erge et al., 2003).Solar panel manufacturing, cell manufacturing, panel manufacturing, and system installation are all handled by three major companies in Malaysia: First Solar, Q-Cells, and Sun Power.

### 2.2.2 Maintenance Management

There has been growing interest among building owners and occupants regarding the potential return on investment associated with adopting sustainable building practices, commonly referred to as "green" buildings. This interest has been fueled by the increasing number of commercial organizations actively pursuing the development of green buildings (Ravindu et al., 2015). It is unsurprising that businesses, regardless of their scale, prioritize the incorporation of green measures into their maintenance plans when promoting their GB (Green Building) services, with a particular emphasis on resolving the lack of GB maintenance. Hence, it is imperative to establish suitable guidelines for the execution of GB maintenance in specific projects, with the aim of identifying areas for enhancement as needed. To meet the demands of their clientele, a significant proportion of maintenance companies in Great Britain strive to optimize the cost-effectiveness of their environmental sustainability endeavors, including the utilization of power, water, and materials (Thatcher and Milner, 2016).

Typically, the evaluation and certification of GB are conducted through the grading systems implemented by individual nations. In Malaysia, the implementation of GB evaluation tools has been undertaken with the aim of attaining the Green Building Index (GBI) certification. This certification is contingent upon the efficient utilization of energy within structures. The aforementioned action was undertaken with the intention of fulfilling the stipulations set forth by the program. The creation and establishment of the Green Building Index (GBI) in Malaysia are overseen by two prominent organizations, namely the Pertubuhan Arkitek Malaysia and The Association of Consulting Engineers Malaysia. The objective is to classify the most exemplary techniques and practices for GB that are now accessible. The authors (Mohammad et al., 2014) observed that the initial stage of the project involved adherence to green principles and project specifications at the silver level. As the project progressed and more intricate and untested technologies were incorporated, the commitment to energy efficiency increased, leading to the attainment of gold or platinum levels.

## 3.Methodology

The objective of this study is to examine the primary determinants of maintenance techniques in the context of solar energy applications or the Green Building Index (GBI) workplaces in

Malaysia. The inquiry employed quantitative methodologies during the data collection process. Sarantakos (1998) posits that social scientists employ quantitative and qualitative methodologies as the primary tools for data analysis throughout research endeavors.

The first stage of the data collection method involved conducting a comprehensive evaluation of the pertinent academic literature. The objective of this activity was to obtain secondary data pertaining to the research topic. The requisite data for the study was acquired from diverse sources, including online journal articles that were accessed and downloaded. Books played a crucial role in the acquisition of essential facts during the literature study.

The final stage of the data collection procedure involved the administration of a survey in the form of a questionnaire. The principal objective of the questionnaire survey was to analyze the factors that impact the maintenance management strategies employed in the implementation of solar technology. To ensure the reliability, impartiality, and significance of the data, the responses and variables pertaining to user and management indications, which were acquired through the survey, were used to authenticate the findings gained throughout the literature review phase of the data gathering process.

The Relative Importance Index (RII) will be used to identify the relation between respondents' agreement and the results achieved. The range of the index can be obtained by using the formula of frequency. The Relative Importance Index (RII) technique was used to analyze the gathered data. The analysis consisted of ranking various variables based on the relative importance indices. Through the analysis, different maintenance management key factors were ranked based on the relative importance indices. The analysis revealed the variables and categories with the highest contribution to green building management in the Malaysian context. The RII formula (Chan and Kumaraswamy 1997; Olomolaiye, Wahab, and Price 1987) is as follows:

$$\textbf{Relative Importance Index} = \frac{\sum w}{AN} = \frac{5n_5 + 4n_4 + 3n_3 + 2n_2 + 1n_1}{5N}$$

The RII (Relative Importance Index) is calculated using the weighting assigned by respondents to each element, which ranges from 1 to 5. A represents the weight with the highest value (which is 5 in this example), and N is the total number of respondents (Kometa, Olomolaiye, and Harris 1994; Ozdemir 2010; Waris et al. 2014). The value of the RII can be anywhere from 0 to 1, with 0 being the lowest possible value. The RII values are then transformed into three important levels in management key practices and green building performance, namely high (H) ($0.8 \leq RII \leq 1$), medium (M) ($0.5 \leq RII < 0.8$), and low (L) ($0 \leq RII < 0.5$) (Sterner 2002; Tam, Tam, and Ng 2007). Since medium means are used in this study, high, medium, and low levels are derived from the RII values. The RIIs of the mean groups can be found by first calculating the average RIIs of the causes that belong to each group. The RII method is applied to the analysis of the gathered data. As part of the analysis, distinct reasons are ranked with respect to RII (Gunduz, Nielsen, and Ozdemir 2012).

## 4. Analysis and Findings

The data for this study were obtained by distributing questionnaires to individuals in managerial positions responsible for maintenance management. A total of 80 participants, all of whom were members of the managerial or maintenance management team, completed the questionnaires. The case studies included Diamond Building Putrajaya, PAM Centre, and Menara Kerja Raya Kuala Lumpur. The questionnaire was developed in accordance with the study objective to ascertain an overview of the research aim.

**Table: 2 Critcal Factors for Maintenance Management Strategies In Solar Energy Applications**

| List Of factors | Degree Of Importance | | | | | Importance Index | Overall Ranking |
|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | | |
| **Strict legislation set by the government** | 0<br>0 | 0 | 4<br>(5%) | 16<br>(20%) | 60<br>(75%) | 0.96 | 1 |
| **Organization's sustainability policy** | 2<br>(2%) | 10<br>(13%) | 2<br>(2%) | 10<br>(13%) | 56<br>70%) | 0.87 | 2 |
| **The commitment and the perception of maintenance manager** | 0 | 2<br>(3% | 20<br>(25%) | 5<br>(6%) | 53<br>66%) | 0.863 | 3 |
| **The methodology of managing physical assets** | 0 | 0 | 22<br>(27%) | 38<br>(48%) | 20<br>25%) | 0.795 | 4 |
| **High qualified technical professional** | 0 | 5<br>(6%) | 10<br>(13%) | 50<br>(63%) | 15<br>18%) | 0.788 | 5 |
| **Facilities and maintenance managers need training and practical tools.** | 0 | 5<br>(6%) | 20<br>(25%) | 45<br>(56%) | 10<br>(13%) | 0.750 | 6 |
| **Sustainable Innovation** | 3<br>(3%) | 10<br>(13%) | 7<br>(9%) | 41<br>(51%) | 19<br>(24%) | 0.74 | 7 |

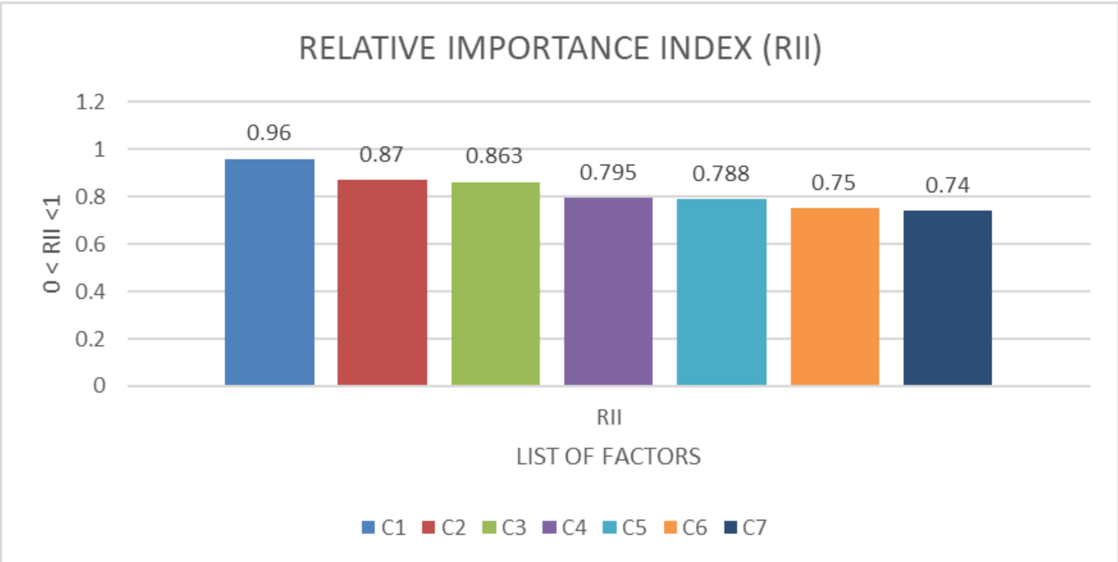


**Figure 1: Relative Importance Index for List of factors**

The provided visual representation displays a table and a bar chart presenting data pertaining to the crucial criteria (C) that raise concerns regarding the long-term sustainability of maintenance management systems for solar energy applications. Based on the aforementioned criteria, the respondents prioritize several factors, including stringent government regulations, the organization's sustainability policy, the commitment and perspective of the maintenance manager, and the chosen method of administering physical assets. The education and tools in the areas of sustainable innovation (75 percent), technological innovation (66 percent), financial innovation (56 percent), and social innovation (56 percent) significantly benefit managers in the disciplines of facilities and maintenance (51 percent). The following are the index values for this set, in sequential order: 0.960, 0.870, 0.863, 0.795, 0.788, 0.750, and

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0.740.

During the second phase of the study, the data provided by the participants was examined and subsequently utilized to guide the process of selecting cases. The calculation of RIIs was performed utilizing the data provided in the conclusion section. Based on the findings of a survey administered to employees of GBI in Malaysia, the key elements in maintenance management strategies for solar energy applications are identified as government regulations, the organization's sustainability policy, the dedication of the maintenance manager, and the manager's perception. The result of this study was established based on the responses obtained from a survey administered to experts in the solar industry involved in the development and implementation of maintenance management plans.

Newly announced government regulations may have the following impact on maintenance management techniques for solar energy applications in Malaysian GBI offices. This is mostly due to the fact that stronger regulations may result in an increase in prices, which may lead to a price increase for solar energy applications. This is due to the possible cost implications of stricter legislation for businesses. Next, a reduced capacity to adapt to novel circumstances. In addition to restricting the variety of solar energy applications, stricter rules may have this effect. It would be more difficult for businesses to adjust to fluctuating market conditions if they were required to comply with tougher restrictions. In addition, tougher rules may hinder the development of the most promising solar energy uses. This is because it may be time-consuming and challenging for businesses to comprehend and comply with more sophisticated requirements. To maintain the reliable operation of their solar energy systems, businesses in Malaysia may need to alter their maintenance management strategies in light of the aforementioned factors. They can utilize highly skilled professionals for equipment maintenance to ensure that solar panels and other machinery stay in excellent shape. This will expedite the identification and resolution of problems and ensure that the organization has staff with the knowledge to do routine maintenance.

The 0.87 RII suggests that the organization's plan for achieving sustainability may influence the maintenance management practices utilized for solar energy applications at the GBI Offices in Malaysia in numerous ways. Initially, greater emphasis is placed on preventative care. A strategy that prioritizes environmental safeguards and resource conservation may result in a greater emphasis on routine inspections and maintenance of solar power equipment. This is due to the fact that preventative maintenance can extend the lifespan of solar panels and other components, resulting in cost savings for the business. According to research conducted by the National Renewable Energy Laboratory, well-maintained solar panels have a potential lifespan of at least 25 years (NREL). According to the study, preventive maintenance can extend the lifespan of solar panels by up to 50 percent.

The dedication and viewpoint of the maintenance manager can have a significant effect on the maintenance management procedures utilized for solar energy applications in GBI-owned and -operated facilities in Malaysia. The maintenance manager is more likely to plan and implement effective maintenance management strategies if he or she places an emphasis on sustainability and preventive maintenance. This is because they are more likely to recognize the benefit of investing in preventative measures that might extend the useful life of solar panels and other components, hence saving money over time. They are more likely to recognize the significance of routine maintenance and invest resources accordingly.

## 5. Conclusion

The purpose of this research was to analyze the most important aspects of maintenance management techniques for solar energy applications in Green Building Index (GBI) offices in Malaysia towards establishing a sustainable environment. Through this research, information about Facility Management (FM), maintenance management, and solar energy systems in Malaysia has been gathered, and the determinant factors that hinder the strategies have been identified through the desktop study. Based on the questionnaire approach, three (3) key factors that contribute to the strategies for maintenance management for solar energy applications have been identified: (i) The government's strict legislation, (ii) the organization's sustainability policy, and (iii) the commitment and perception of the maintenance manager. The results were achieved through the analysis of a distributed questionnaire among experts. RII was evaluated, considering all factors, and based on the knowledge and consciousness of green building experts, managers, and facilitators in Malaysia, they were ranked.

## 6. Recommendation for Future Research

Based on the findings and insights obtained from this study regarding the key factors influencing maintenance management techniques for solar energy applications in GBI-certified green buildings in Malaysia, various suggestions for future research may be put forward. First and foremost, it is necessary to carry out longitudinal studies in order to observe the long-term performance and effectiveness of the maintenance management solutions that have been established in green buildings. Gaining insight into the long-term viability and flexibility of these techniques can offer valuable direction for ongoing enhancement and optimization.

Additionally, it is recommended that future studies investigate the incorporation of developing technologies and innovations within the realm of solar energy maintenance management systems. The exploration of artificial intelligence, Internet of Things (IoT) devices, and advanced data analytics in the context of maintenance practices holds promise for the development of more intelligent and efficient maintenance strategies. Furthermore, it is suggested that further research be undertaken on comparative studies that examine maintenance management systems across various green building certifications or sustainability standards. Gaining an understanding of the similarities and variations in tactics can facilitate the identification of optimal approaches and promote the exchange of knowledge across industries.

In addition, it is imperative to analyze the involvement of various stakeholders, including occupants, facility managers, and policymakers, in order to effectively execute maintenance management techniques for solar energy applications. Gaining insight into the viewpoints and level of engagement of different stakeholders can offer a thorough understanding of the obstacles and possibilities associated with the advancement of sustainable solar energy utilization in environmentally friendly structures.

Finally, there is a need for research that explores the economic and financial dimensions of maintaining solar energy systems in environmentally friendly structures. Evaluating the cost-benefit analysis, return on investment, and life-cycle assessment of various maintenance solutions can aid decision-makers in making well-informed choices that align with both environmental and financial objectives.

## References

Abdollah pour E, Nejat S, Nourozian M, Majdzadeh R. The process of content validity in instrument development.Iranian Epidemiology.2010;6(4):66–74

Ahmad, N.A. (2014). Solar 'Kampong': Community Power Supply For Low-Income Households In Rural Malaysia. Retrieved from https://researchspace.auckland.ac.nz/handle/2292/25564

Ahmad, N.A., Ahmad, A.C, Byrd, H., & Hussain, N.H. (2019). Establishing Solar Village Communities in Malaysia towards a Self-Sufficient Electricity Lifestyle: The Feasibility Study. Retrieved March, 2019, from https://www.ijitee.org/wp content/uploads/papers/v8i5s/ES3428018319.pdf

Aziz, A., W., Arief, Y. Z., & Aziz, A. (2016). Evaluation of Solar Energy Potential in Malaysia. Trends in Bioinformatics, 9(2). Retrieved from https://scialert.net/abstract/?doi=tb.2016.35.43

Baranski, A. (2018). Solar PV: Advantages and Disadvantages of Solar Panels. Retrieved September 1, 2018, from https://www.profolus.com/topics/solar-pv-advantagesand-disadvantages-of-solar-panels/

Chen, H., & Li, J. (2022). Facilities Management in the Public Sector: A Strategic Perspective. Public Administration Review, 42(3), 378-391.

Chen, H., Lee, S., & Johnson, R. (2018). ASHRAE 62.1 and Indoor Air Quality: A Review of Strategies for Improved Ventilation Performance. Journal of Indoor Environmental Quality, 15(3), 120-136.

Chowdhury, S., Rahman, M., & Smith, R. (2022). Solar Energy Applications in Malaysia: A Comprehensive Review. Journal of Renewable Energy, 37(1), 45-58.

El Ammari, K., & Hammad, A. (2019). Remote interactive collaboration in facilities management using BIM-based mixed reality. *Automation in Construction*, *107*, 102940.

Jensen, P.A., Nielsen, S.B. and Rasmussen, H.L. (2023), "Collaboration between researchers and practitioners on developing facilities management standards and guidelines", *Facilities*, Vol. 41 No. 5/6, pp. 357-371. https://doi.org/10.1108/F-06-2022-0091

Jones, R., & Smith, P. (2021). Sustainability and Organizational Change: A Comprehensive Approach. Journal of Sustainable Business, 15(2), 87-102

Patacas, J., Dawood, N., & Kassem, M. (2020). BIM for facilities management: A framework and a common data environment using open standards. *Automation in Construction*, *120*, 103366.

Renewable Energy Act, Revised Law of Malaysia Act 725 (2011). Retrieved from the SEDA website: http://www.seda.gov.my/policies/renewable-energy-act-2011/

Richardson, M. (2010). Energy and geopolitics in the South China Sea. Retrieved June, 2022,from https://www.researchgate.net/publication/291064501_Energy_and_geopolitics_in_the_South_China_sea

Rock, S., Hosseini, M.R., Nikmehr, B., Martek, I., Abrishami, S. and Durdyev, S. (2019), "Barriers to "green operation" of commercial office buildings: Perspectives of Australian facilities managers", *Facilities*, Vol. 37 No. 13/14, pp. 1048-1065. https://doi.org/10.1108/F-08-2018-0101