JICE Journal Innovation of Civil Engineering

Vol. 5, No. 2, pp. 82-91, 2024
Submit: 20-11-2024 |
Accepted: 04-12-2024 |
Publish: 24-12-2024 |

COMPARATIVE STUDY OF BGH PUPR AND GREENSHIP ASSESSMENT CRITERIA ON SGLC BUILDING UGM

Cynthia Permata Dewi[1*], **Arif Kusumawanto**[2]

[1] Civil Engineering Department, Universitas Negeri Malang, Malang, 65144, Indonesia
[2] Department of Architecture and Planning, Universitas Gadjah Mada, Yogyakarta,55281, Indonesia

e-mail: cynthia.dewi.ft@um.ac.id

ABSTRACT

The use of green building concepts is growing in response to global climate change and the impact of CO2 emissions. Green building assessment systems have emerged in various countries around the world as a basis for assessing the green level of buildings. Indonesia has two green building assessment systems, namely BGH assessment based on PUPR minister's regulation no 21 of 2021 and Greenship. This research aims to find out the similarities and differences between the two systems and how they are applied to green buildings at SGLC UGM as a case study. This research uses a comparative descriptive method through BGH and Greenship documents. The results showed that both assessment systems have some similarities in terms of energy efficiency, water, waste management and support for the use of renewable energy. The differences between the two systems include certification bodies, document requirements, assessment stages and standard references used. The application of the assessment system to the UGM SGLC building through the BGH candy checklist approach resulted in a score of 66% and a score of 52 on the Greenship assessment. demonstrating that achieving middle-level BGH and Greenship performance is attainable through integrated sustainable design, which serves as a benchmark for future projects aiming to balance environmental performance with local conditions, thereby advancing Indonesia green building agenda and supporting national sustainability goals.

Keywords: *BGH; Greenship; Green Building Assessment.*

1. Introduction

Increasing greenhouse gas emissions dissertated with CO_2 are the impact of various human activities, especially the construction industry sector which contributes about 40% of emissions. [1]-[3]. The concept of green building emerged as a solution to overcome environmental problems caused by the building sector. Green buildings are designed to minimize negative impacts on the environment throughout their life cycle, from planning, and construction, to operation and demolition. [4]-[6]. Along with the increasing interest in green buildings, there is a need for a standard that can be used to measure the environmental performance of a building. This standard is needed to ensure that all buildings claiming to be "green" meet the same criteria, the existence of an assessment standard also allows comparison of performance between green buildings and increases public confidence in the sustainability claims of a building.

Indonesia, as a developing country with rapid economic growth, is experiencing an increasing demand for building space. This rapid growth of the property sector has the potential to increase pressure on the environment if not managed properly. In this context, the Green Building Council Indonesia (GBCI) developed a green building rating system known as Greenship. This system is specifically designed for Indonesian conditions, taking into account the country's climatic characteristics, culture, and regulations. Greenship has an important role in the development of green buildings in Indonesia. One of the functions of Greenship is to popularize the concept of green

Vol. 5, No. 2, pp. 82-91, 2024
Submit: 20-11-2024 |
Accepted: 04-12-2024 |
Publish: 24-12-2024 |

building in Indonesia and encourage construction industry players to apply the principles of sustainability, create a healthy, comfortable, and energy efficient built environment, reduce energy, water, and raw material consumption and minimize waste production [7].

Greenship has evolved from version 1.0 to the current version 1.2. Version updates are made by making several adjustments, including adjustments to technological and regulatory developments, namely updates to technology and best practices in the construction industry. Adjustments to regulatory changes are made related to green building and the environment. In addition to adjustments, improvements were also made to the assessment criteria, increasing transparency and openness and focusing on innovation. Allocating greater weight to the use of renewable energy in buildings was done in the Greenship version 1.2 regulation apart from tightening requirements related to the use of recycled materials and low impact on the environment. Other assessment factors were adjusted to pay greater attention to indoor air quality, daylighting and acoustics.

In addition to Greenship, which is an assessment institution outside the government, the government through the PUPR office issued an assessment system for the performance assessment of green buildings in 2021. In the green building performance assessment (BGH) regulation, the assessment is carried out on several types of buildings, namely new buildings, existing buildings, houses and areas. The assessment is also differentiated in stages, each type of building has a different value and assessment stages. The BGH performance assessment is carried out by an assessment team consisting of BGH consultants who have expertise in designing and evaluating green buildings, academics consisting of lecturers and researchers from universities that have green building-related study programs can provide an academic perspective, professionals from certification bodies, and government officials from relevant agencies, such as the Public Works Office, can be involved in the assessment process to ensure compliance with regulations.

This research aims to compare and analyze the PUPR standard green building assessment system and Greenship Indonesia. The research questions include: what are the similarities and differences between the two rating systems; what criteria are the main focus of each system; and how are the two systems implemented in the field. The results of this research are expected to contribute to the construction industry players, government, and academics in choosing the right assessment system and improving the quality of green buildings in Indonesia.

2. Material and Methods

2.1. Green Building

Green building technology is an idea that emerged in response to global climate change conditions that occur [8]. Green building is a term that refers to the principle of sustainable building through the fulfillment of certain criteria that adhere to the principle of energy conservation [9]. Chatwani (2018) states that green building refers to both the structure and utilization process by the principles of environmental friendliness and resource efficiency throughout the building's life cycle [4]. Green building technology is also referred to as a technology that serves to minimize the negative impact on the environment and can fulfill the function of the building itself on the comfort and productivity of building users [10]. Green building can also be seen as a technological strategy that can optimize the design through the adoption of renewable energy technology, and passive building technology appropriately [10][2].

2.2. Green Building Rating System

A green building rating system is a framework used to evaluate the environmental performance and sustainability of a building [11]. This system sets the criteria that a building must meet in order to be called a green building. The criteria cover various aspects, ranging from energy efficiency and water use, material selection, and indoor air quality, to the social and economic impacts of the building.

There are several main objectives of implementing a green building rating system, the first of which is to promote sustainable development [12]. By setting clear standards, the rating system

JICE Journal Innovation of Civil Engineering
Vol. 5, No. 2, pp. 82-91, 2024
Submit: 20-11-2024 |
Accepted: 04-12-2024 |
Publish: 24-12-2024 |

encourages the construction of more efficient, environmentally friendly, and sustainable buildings. The second objective is to improve the quality of the built environment. Green buildings can help reduce negative impacts on the environment, such as greenhouse gas emissions and air pollution. The third objective is to improve occupant health and comfort. Green buildings are designed to provide a healthier and more comfortable environment for occupants, with good indoor air quality, adequate natural lighting, and controlled room temperature. The fifth objective is to increase asset value. Green buildings generally have higher sales and rental values than conventional buildings. The next goal is to encourage innovation through green building assessment. A green building rating system encourages innovation in building technology and materials, creating new solutions to environmental challenges.

The concept of green building has been around for a long time, but modern green building rating systems began to develop in the late 20th century. One of the first green building rating systems to emerge was LEED (Leadership in Energy and Environmental Design) developed by the US Green Building Council (USGBC) in 1998 [13]. LEED is one of the most well-known and widely used green building rating systems in the world. Another international rating system is BREEAM (Building Research Establishment Environmental Assessment Method) developed in the UK, BREEAM is a comprehensive green building rating system and has been applied in many countries.

The development of green building regulations in Indonesia cannot be separated from the role of the government which encourages the use of green building concepts in supporting a sustainable environment. In Indonesia, awareness of the importance of green buildings is increasing, thus encouraging the development of local green building rating systems. One of the most popular green building rating systems in Indonesia is Greenship, developed by the Green Building Council Indonesia (GBCI) [14].

Greenship is a green building rating system developed specifically for Indonesian conditions and contexts by the Green Building Council Indonesia (GBCI). This system was launched with the aim of encouraging the development of more sustainable and environmentally friendly buildings in Indonesia. Indonesia's specific conditions encourage the emergence of Greenship to be able to accommodate Indonesia's climate needs along with its cultural diversity and various development sector challenges. Greenship aims to improve the quality of buildings in Indonesia, both from an environmental, social and economic perspective. This system is in line with the sustainable development goals set by the Indonesian government. [15].

Important aspects that fall within the scope of the Greenship assessment include: Energy efficiency which includes the use of renewable energy, lighting efficiency, and energy-efficient HVAC systems. Another aspect is water usage. This aspect includes reducing water consumption, managing rainwater, and using greywater. Material aspects are also included in the Greenship assessment. The use of local materials, recycled materials, and materials with low carbon emissions affect the assessment points on the Greenship. Indoor air quality is also considered in the Greenship assessment aspect. Indoor air quality control, use of natural ventilation, and selection of materials with low VOC (Volatile Organic Compounds). Waste management in this case is the reduction, recycling, and composting of waste is one of the important assessment aspects of Greenship. The last aspect that needs to be highlighted is innovation. The application of innovative technologies and solutions in the field of green building.

In development, the green building assessment standard in Indonesia is the emergence of a green building assessment standard issued by the Ministry of Public Works and Public Housing (PUPR) in 2021. The green building assessment standards set by the PUPR Ministry are the result of awareness of the importance of sustainable development in Indonesia. Along with increasing attention to environmental issues and climate change, the Indonesian government encourages the construction sector to adopt more environmentally friendly practices. The green building assessment standards set by PUPR have a strong legal basis. Relevant laws and regulations include: Law No. 28 of 2002 on Building: This law is the legal basis for all building construction activities in Indonesia, including green building. Other legal basis comes from Government Regulations and Ministerial Regulations. The central and local governments issue various implementing regulations that are more specifically related to green building, including assessment standards. After the issuance of Law 28 of 2002,

Vol. 5, No. 2, pp. 82-91, 2024
Submit: 20-11-2024 |
Accepted: 04-12-2024 |
Publish: 24-12-2024 |

followed by Law 30 of 2007 on energy. [16]. Then in 2011 a regulation was issued by the Minister of Environment on criteria and certification of green buildings. In 2011, Presidential Instruction No. 13 of 2011 on energy and water saving was announced. In 2015, the Minister of Public Works and Public Housing issued a regulation on green building no 02/PRT/ 2015. This regulation was then updated in line with the development of public awareness and the increasing complexity of problems with the Minister of Public Works and Public Housing Regulation No. 9 of 2021 concerning Guidelines for Implementing Sustainable Construction and Minister of Public Works and Public Housing Regulation No. 21 of 2021 concerning Green Building Performance Assessment in order to support environmentally friendly and sustainable infrastructure.

BGH assessment standards by PUPR include energy efficiency, water usage, material selection, indoor air quality, waste management, the surrounding environment, and occupant health and comfort. Energy efficiency emphasizes the efficient use of energy, the application of renewable energy systems, and the optimization of the use of natural energy. Meanwhile, water use refers to reducing water consumption, using rainwater, and managing waste water. Material selection includes the use of local materials, recycled materials, and materials with low carbon emissions. Related to indoor air quality that must be considered is the control of indoor air quality, the use of natural ventilation, and the selection of materials with low VOC (Volatile Organic Compounds). Waste issues that are included in the assessment points are waste reduction, recycling, and composting. The surrounding environment aspect here includes the influence of the building on the surrounding environment, such as green land management and biodiversity conservation. The last aspect to be assessed is the health and comfort of occupants which can be influenced by building designs that support occupant health and comfort, such as adequate natural lighting, good acoustics, and comfortable room temperatures.

2.3 Method

This research uses a comparative descriptive method by comparing green building assessment regulations and Greenship by GBCI and its implementation in green buildings in the UGM area. SGLC building in Faculty of Engineering UGM has been certified green in the design recognition phase. For the final assessment stage, this building could improve its performance so that SGLC would get a better rank in green building assessment result. The research starts from the literature review stage through primary and secondary data collection. Best practice implementation of green buildings in the UGM area was chosen as an object to facilitate understanding of green building applications. The data in this research is in the form of working drawing data, as well as assessment forms based on Greenship and PUPR minister’s regulation regarding BGH assessment, and object documentation through surveys. Secondary data is obtained through literature studies related to Greenship and BGH assessment. Analysis is carried out by identifying, and comparing similarities and differences in the Greenship and BGH assessment systems.

Data Collection Validation for this study were taken from data related to the SGLC building’s performance (e.g., energy consumption, water usage, material specifications, and design features) are sourced from reliable and verified documentation such as design blueprints, operational records, and energy audits which have been published on the previous study. Independent third-party assessments are used to cross-check the accuracy of the data based on the ongoing performance of the building by observation. For the final assessment score and certification process it need to clarify how is the building performance, improvement or changes made to the building that can affect the total performance of the building.

JICE Journal Innovation of Civil Engineering
Vol. 5, No. 2, pp. 82-91, 2024
Submit: 20-11-2024 |
Accepted: 04-12-2024 |
Publish: 24-12-2024 |

Figure 1. Research framework

In new building objects, both the greenship assessment and the PUPR BGH assessment have several stages of assessment. In greenship, the assessment is divided into the design recognition stage and the final assessment stage. Meanwhile, the PUPR BGH assessment system for new buildings is divided into four stages of assessment, namely the planning stage, the implementation stage, the utilization stage, and the demolition stage. In this research, the study analysis will be carried out on new building objects at the design recognition stage for greenship and the planning stage for BGH PUPR assessment. The analysis is conducted to identify similarities and differences between the two assessment systems at similar stages. Best practice is the end of the study that shows green building projects in the UGM campus area that have obtained certification.

3. Result and Discussion

3.1. Similarities and differences between the two systems

Basically, both the green building assessment issued by the Ministry of Public Works and Public Housing (PUPR) and the Green Building Council Indonesia (GBCI) have the same goal, which is to encourage the development of sustainable and environmentally friendly buildings. Although there are differences in some aspects, these two methods also have a number of similarities in their assessment criteria.

Both assessment systems have the same focus on environmental aspects, including energy efficiency, water use, material selection, waste management, and indoor air quality. The methods of both systems are also quite comprehensive because they cover aspects that affect the environmental performance of a building, from the planning stage to utilization.

Some aspects of the assessment that the two systems have in common are the use of renewable energy. Both systems encourage the use of renewable energy sources such as solar panels, wind turbines, or geothermal energy to reduce dependence on fossil energy. Another similarity is that both BGH PUPR and GBCI assessment systems emphasize optimizing the performance of HVAC (Heating, Ventilation, and Air Conditioning) systems, lighting, and other electrical equipment to reduce energy consumption. Another similarity shared by the two systems is that both assess the quality of insulation, sealing, and building design that can minimize heat or cold loss, thereby reducing cooling or heating loads.

Table 1. Aspects of different green building rating systems

Aspects	BGH PUPR	GBCI
Certification Body	KAN-accredited national certification body	GBCI or GBCI licensed institution
Document Requirements	General, in accordance with laws and regulations	Detailed and specific, including building performance data
Assessment Stages	Registration, verification, inspection, certification	Registration, documentation, review, inspection, certification
Standard foundation	SNI	International - general

Vol. 5, No. 2, pp. 82-91, 2024
Submit: 20-11-2024 |
Accepted: 04-12-2024 |
Publish: 24-12-2024 |

It can be seen the difference between the two green building assessment systems based on PUPR and GBCI standards. Green building certification based on PUPR standards is generally carried out by certification bodies that have been accredited by the National Accreditation Committee (KAN). This certification body can be a government or private institution that meets the requirements set by KAN. On the other hand, green building certification based on the GBCI system is carried out by the Green Building Certification Institute (GBCI) or institutions that have obtained a license from GBCI. This certification process is generally more globally standardized.

In more detail regarding document requirements, in the PUPR BGH system, the document requirements that must be submitted for PUPR BGH certification usually include building planning, implementation, and monitoring documents. These documents must comply with the standards set out in the relevant laws and regulations. Whereas in the GBCI system, GBCI document requirements are more detailed and specific. In addition to planning and implementation documents, building performance data is usually also required after the building operates.

BGH PUPR assessment stages generally include registration, document verification, field inspection, and certificate issuance. This assessment process can be carried out at various stages of development, starting from the planning stage until the building is operational. In the PUPR BGH assessment, the object of assessment is divided into new buildings, existing buildings and areas. In new buildings, the assessment aspects include planning, implementation, utilization, and demolition. While in existing buildings, the assessment aspects are carried out at the utilization and demolition stages. On an area scale object, the PUPR BGH assessment.

In the BGH assessment standard, the certification categories are divided into three, namely the main BGH certificate, intermediate BGH certificate, and primary BGH certificate. The main BGH certificate is given to buildings that meet the assessment at 80-100% of the total score. In the intermediate BGH certificate, the certificate is given on the assessment of 65-80% achievement and the Pratama certificate is given to the assessment results that meet 45-65% of the total value. The entire certification is based on a performance checklist. In the planning stage, the aspect with the most points is in the aspect of energy use efficiency. [17]. The aspect of energy use efficiency is divided into several sub-criteria ranging from building envelopes, ventilation systems, air conditioning systems, lighting systems, transportation systems in buildings, energy efficiency calculations, electrical systems, with the most points in the lighting aspect of 12 points and building envelopes of 9 points.

GBCI has two certification systems, the first through greenship certification and the second through edge certification. Greenship certification has four ratings, namely bronze, silver, gold and platinum. [18]. The certification is given at each stage of the greenship assessment, both design recognition and final assessment. In the greenship assessment, the aspect with the biggest points at the DR and FA stages is in the EEC (Energy Efficiency and Conservation) aspect of 26 points. In EEC, the prerequisite criteria that must be met are the installation of sub meters (EEC-P1) and OTTV calculations (EEC-P2). As for the credit criteria, EEC 1, namely energy saving measures, has the highest score with 20 points. EEC 1 aims to encourage energy savings through the application of energy efficiency measures. This goal is achieved through several benchmarks, including: using Energy modeling software to calculate energy consumption in baseline and designed buildings. Secondly, using worksheet calculations, every 2% saving from the difference between the designed and baseline building gets 1 value. Third, using calculations per component separately, namely the OTTV value, artificial lighting, vertical transportation, and air conditioning systems. [14].

JICE Journal Innovation of Civil Engineering

Vol. 5, No. 2, pp. 82-91, 2024
Submit: 20-11-2024 |
Accepted: 04-12-2024 |
Publish: 24-12-2024 |

3.2. Implementation of the BGH Assessment Application of PUPR Minister's Regulation no 21 of 2021 and Greenship in the UGM SGLC (Smart Green Learning Center) Building

Figure 2. Location map of SGLC UGM building
Source. Google Earth

Smart Green Learning Center UGM is one of the buildings in the UGM area in the engineering faculty that applies the green building concept. Based on the results of the analysis referring to the list of references from Permen PUPR no 21 of 2021, the SGLC UGM building in accordance with the planning stage of the new building obtained an estimated score of 66% so that it was estimated that it could enter the intermediate BGH category. Meanwhile, based on the estimated assessment based on the results of the greenship assessment analysis, it obtained a score of 62 and entered the gold category.

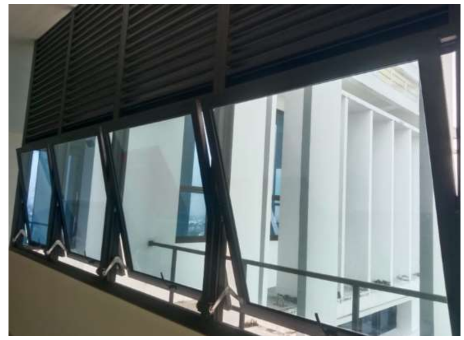
The first analysis predicts an assessment based on the BGH assessment of PUPR candy no 21 of 2021. Some aspects that have the maximum score on the SGLC building are achieved at the building orientation point because the building orientation in the east west direction has a ratio of almost 2 times the length of the north south direction. In the aspect of site processing, the albedo value is in the range of 0.35 with the use of gray concrete. In addition, the presence of rain water tanks also helps in site assessment points.

Figure 3. SGLC building outdoor space area

The engineering aspect of passive design with maximum assessment points is also achieved by the openings in the SGLC building spaces. Not only is it possible to utilize natural lighting, but also natural ventilation can be maximally utilized. Especially corridor spaces that do not use artificial air conditioning. This is in accordance with the ventilation system assessment points on the checklist guidelines that corridor areas, elevator lobbies and toilets do not use artificial ventilation, so they can get maximum points. The ground floor is partially designed as an open space so as to maximize natural lighting and ventilation.

JICE Journal Innovation of Civil Engineering

Vol. 5, No. 2, pp. 82-91, 2024
Submit: 20-11-2024 |
Accepted: 04-12-2024 |
Publish: 24-12-2024 |



(a) (b)

Figure 4. (a) Open space area on the ground floor (b) window design for passive design

Another assessment that has the potential to achieve maximum scores is on indoor air quality. The presence of CO_2 sensors contributes to the maintenance of CO_2 content in the room air. commitment to waste management with the 3R principle is also carried out by providing waste bins that are sorted by type.

The second analysis predicts the greenship assessment at the design recognition stage. The first point in the ASD (Appropriate Site Development) category, the fulfillment of prerequisites is achieved by the presence of landscaping areas in the form of softscape vegetation in the building area by the criteria in the Minister of Public Works Regulation No. 5/PRT/M/2008 regarding Green Open Space (RTH). The existence of the SGLC building provides the potential to avoid the use of motorized vehicles with the existence of access that is free from intersections with motorized vehicle access. So that the community accessibility category can obtain a fairly high score. The existence of bus stops with a distance of less than 300m supports the ASD 3 assessment category, namely public transportation.

Figure 5. Open space on the ground floor

In the classroom area, daylighting is the priority system used. The addition of horizontal louvres helps reduce glare from sunlight entering the room. the presence of lux sensors in the building also adds to the assessment score in the EEC2 category. EEC 3 points get the maximum score because in transitional space areas such as corridors, stairs or elevator lobbies do not use the help of mechanical equipment. The presence of solar panels on the roof of the SGLC building makes the maximum contribution to the EEC 5 category.

Vol. 5, No. 2, pp. 82-91, 2024
Submit: 20-11-2024 |
Accepted: 04-12-2024 |
Publish: 24-12-2024 |

Figure 6. Classrooms in the SGLC UGM building

The results of the study on green building practices in the SGLC building at UGM demonstrate the importance of integrating sustainable design principles early in the planning process to achieve high-performance outcomes in energy efficiency, water conservation, and indoor environmental quality. The building's implementation of passive design strategies, effluent, and green building techniques have significant implications for the advancement of green building practices in Indonesia. This case study emphasizes the need for more widespread adoption of Greenship standards, especially with regard to minimizing environmental impacts while addressing Indonesia's unique climate challenges. If these practices are replicated, they could significantly contribute to the national sustainability targets and foster a culture of green innovation in the construction industry.

4. Conclusions

The green building assessment system by greenship and PUPR candy no 21 of 2021 have several similarities in terms of the focus of assessment on energy efficiency, water use, material selection, waste management, and indoor air quality. In addition, both assessment systems also encourage the use of renewable energy. In addition to similarities, there are several kinds of differences owned by the two systems, including institutions that carry out certification, document requirements, assessment stages, and standard references used. The implementation of the estimated assessment results on the SGLC UGM green building shows results equivalent to the middle BGH level with a score range of 66% and at the greenship assessment at the gold level with a score range of 52.

Future research should focus on exploring strategies to improve the sustainability performance of green buildings especially in the evaluation of occupant behavior and its impact on building performance. Understanding how users interact with the building's green features could provide insights for designing more user-friendly and adaptive systems.

Acknowledgments

The authors would like to express gratitude to the Indonesia Endowment Fund for Education (LPDP, Lembaga Pengelola Dana Pendidikan) for their support during the author's study.

References

[1] .Liaoand L. Li, "How can green building development promote carbon emission reduction efficiency of the construction industry-Based on the dual perspective of industry and space," *Environ. Sci. Pollut. Res.*, vol. 29, no. 7, pp. 9852-9866, 2022, doi: 10.1007/s11356-021-16380-2.

[2] .Liu*et al.*, "Sustainability Considerations of Green Buildings: A Detailed Overview on Current Advancements and Future Considerations," *Sustain.*, vol. 14, no. 21, pp. 1-23, 2022, doi: 10.3390/su142114393.

[3] .R. Syahriyah,"Application of Green Material Aspects to the Building Criteria of

Vol. 5, No. 2, pp. 82-91, 2024
Submit: 20-11-2024 |
Accepted: 04-12-2024 |
Publish: 24-12-2024 |

Environmental Houses in Indonesia," *J. Lingkung. Binaan Indones.*, vol. 6, no. 2, pp. 100-105, 2017, doi: 10.32315/jlbi.6.2.95.

[4] .Chatwani, K. Prajapat, and P. K. Meena, "Reducing CO2 emission through Green Building design," no. March, 2018.

[5] . Jaradat, O. A. M. Alshboul, I. M. Obeidat, and M. K. Zoubi,"Green building, carbon emission, and environmental sustainability of construction industry in Jordan: Awareness, actions and barriers," *Ain Shams Eng. J.*, vol. 15, no. 2, p. 102441, 2024, doi: 10.1016/j.asej.2023.102441.

[6] .Shen and M. Faure,"Green building in China," *Int. Environ. Agreements Polit. Law Econ.*, vol. 21, no. 2, pp. 183-199, 2021, doi: 10.1007/s10784-020-09495-3.

[7] . N. A. Siadari, Y. Chairin, and E. Erizal, "Comparative Study of Green Building Assessment of New Buildings Using the Greenship New Building Version 1.2 and Version 2.0 Systems," *Civil Engineering*, vol. 17, no. 2, pp. 153-160, 2023, doi: 10.21776/ub.rekayasasipil.2023.017.02.6.

[8] .H. Ahram and S. A. S. Zakaria,"The contribution of green building in reducing the carbon footprint and attaining SDG 13," *IOP Conf. Ser. Earth Environ. Sci.*, vol. 1205, no. 1, 2023, doi: 10.1088/1755-1315/1205/1/012034.

[9] .S. Pangkey, P. Puspitasari, and D. Rosnarti, "Green Industrial Materials in Architectural Building Facade Design," *Pros. Semin. Intelekt. Muda*, vol. 3, no. 2, pp. 255-260, 2022.

[10] . Gibberd,"Green building technologies," *Cases Green Energy Sustain. Dev.*, no. June, pp. 482-510, 2019, doi: 10.4018/978-1-5225-8559-6.ch017.

[11] Widyawati and R. Laksmi,"Green Building in Sustainable Development Energy Saving Concept Towards Green Building in Jakarta," *J. Kalibr*., vol. 2, no. 1, pp. 43-59, 2019, [Online]. Available: https://ejournal.borobudur.ac.id/index.php/teknik/article/view/463.

[12] .Lai, J. Zhou, L. Lu, M. Hasanuzzaman, and Y. Yuan,"Green building technologies in Southeast Asia: A review," *Sustain. Energy Technol. Assessments*, vol. 55, no. November 2022, p. 102946, 2023, doi: 10.1016/j.seta.2022.102946.

[13] .Marchi, E. Antonini, and S. Politi,"Green Building Rating Systems," *Encycl. Sustain. Technol.*, pp. 99-112, 2017, doi: 10.1016/B978-0-12-409548-9.10187-3.

[14] GBCI,"GREENSHIP Rating Tools," *Greensh. New Build. Version 1.2*, no. April, pp. 1-15, 2013, [Online]. Available: http://elib.artefakarkindo.co.id/dok/Tek_Ringkasan GREENSHIP NB V1.2 - id.pdf.

[15] . Kusumawanto and Z. B. Astuti, "Green Architecture in Innovation City Architecture." Gadjah Mada University Press, Yogyakarta, 2021.

[16] . W. Kadek, I. Kumara, and R. Sari Hartati,"Literature Study of Green Building Development in Indonesia," *J. SPEKTRUM*, vol. 8, no. 2, p. 37, 2021, doi: 10.24843/spektrum.2021.v08.i02.p5.

[17] Ministry of PUPR, "Minister of Public Works and Housing Regulation of the Republic of Indonesia Number 21 of 2021," *Minister of Pekerj. Public Works and Housing. People of the Republic of Indonesia*, vol. 21, pp. 95-140, 2021.

[18] .L.A. Sucipto, J. U. D. Hatmoko, S. Sumarni, and J. Pujiastuti, "Study of Green Building Implementation in Surakarta Bank Indonesia Building," *J. Ilm. Educ. Tek. and Kejuru.*, vol. 7, no. 2, 2017, doi: 10.20961/jiptek.v7i2.12692.