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Optimization of Stadium Building Operational Costs by Implementing Green Building Design Concepts

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Abstract: Currently, all buildings constructed by the government are required to implement the Green Building (BGH) principles. In addition to complying with existing regulations, the implementation of BGH also offers several benefits, including creating more environmentally friendly buildings and achieving more efficient operational costs. In this study, the method used involved collecting data from survey reports at three stadiums, namely Patriot Candrabhaga Stadium in Bekasi city, Wibawa Mukti Stadium in Bekasi regency, and Harapan Bangsa Stadium in Banda Aceh. However, this study focuses only on survey data from Wibawa Mukti Stadium in Bekasi regency, West Java, due to its similar spectator capacity and electrical system. Subsequently, a redesign of the electrical system was carried out by implementing the BGH concept. After the construction phase based on the electrical system design following the BGH principles was completed, The author conducted a check on electricity usage to understand electricity consumption after the renovation. Based on the author's observations, electricity consumption before and after implementing the BGH concept showed a significant decrease. Electricity consumption before the improvements was recorded at an Active Power of 13,227.36 kWh and a Reactive Power of 10,251.15 kVARh. Meanwhile, after the improvements, electricity usage showed an Active Power of 5,926.85 kWh, and Reactive Power was not calculated because the cos phi value of 0.93 exceeded the minimum penalty limit set by PLN at 0.85. There was an electricity savings of 7,300.51 kWh in one month, which means a 55% savings in kWh payments and 100% in kVARh payments. This indicates that the implementation of the BGH concept can effectively reduce electricity consumption in a building, which in turn will contribute to reducing the load on conventional power plants reducing the burden on conventional power plants that are not environmentally friendly.

Keyword: Energy Saving, Environmentally Friendly, Cost Efficiency

INTRODUCTION

Football is one of the most popular sports in Indonesia, enjoyed by all segments of society, whether young, old, men, or women. The development of football in Indonesia is improving and progressing, both at the national and international levels. This can be seen from the ongoing Indonesian league tournaments, which will enhance healthy competition among clubs, and it is hoped that they will produce the best talents in Indonesia, subsequently boosting the achievements of the Indonesian national team in international tournaments.

Therefore, the government is committed to supporting the advancement of Indonesian football by building and renovating stadiums in Indonesia according to FIFA (Federation Internationale de Football Association) standards, so that Indonesian players become accustomed to playing at international standards.

Almost all major cities in Indonesia have football stadiums with a fairly large spectator capacity (more than 20,000 spectators). This requires significant operational costs for maintenance and upkeep. Currently, operational costs are borne by the local government through the regional budget (APBD), which is often insufficient, while revenue relies solely on event matches. This situation becomes even more challenging if the club in that city no longer participates in the Liga 1 or Liga 2 competitions, resulting in no match events to generate income for the stadium management, while the stadium still requires costs for building maintenance and utilities.

Therefore, in designing stadiums in Indonesia, it is also necessary to consider a system that has minimum operational costs and is energy-efficient. The concept of developing a Stadium Electrical Power Distribution System with a Green and Sustainability approach is one method to achieve this goal. This approach will result in an effective and efficient design that will provide more profitable investment impacts. The Green and Sustainability approach is outlined in several aspects as follows:

a. Efficient in energy use.
b. Exploration of the use of renewable energy.
c. Energy-saving recommendations through optimizing passive building design using Energy Software control. (Sizing of Utility Equipment will be optimal)
d. Prioritizing ease and reliability in operation and maintenance through a centralized system.
e. Implementation of Maintenance & Energy Monitoring System.

This research related to the implementation of the Green Building concept has begun since the enactment of PUPR Regulation No. 21 of 2021 concerning the performance assessment of Green Building Structures. Here are some recent studies: Analysis of Energy Efficiency in the Animal Science Learning Center Building using GBCI, EDGE, and BGH PUPR rating tools (Muhammad Ihsan Sofwan, 2025), Analysis of Energy Efficiency in Green Buildings with the Latest Technology (Reja Putra Jaya, Angga Setyadi Tommy, Greget Widhiati, Widya Ariyani, 2025)

METHOD

The research method of used a qualitative descriptive method with a case study approach. Qualitative research is a type of research that is descriptive in nature and tends to seek meaning from data obtained from the results of a study. This type of case study approach is used to investigate and understand an event or problem that has occurred by gathering various kinds of information. The research phase begins with conducting a survey at the location by making of observations, measurements, and Discussion with the stadium building manager. The next stage involves analyzing and summarizing the data which is obtained from the field or location. Then, an electrical distribution design is created based on the results of the field data analysis.

After that, construction work is carried out by the executing contractor according to the design that has been made. In the final stage, a review and analysis are conducted on the repair work to ensure it complies with the applicable standards and regulations. Figure 1 describes a research methodology stages

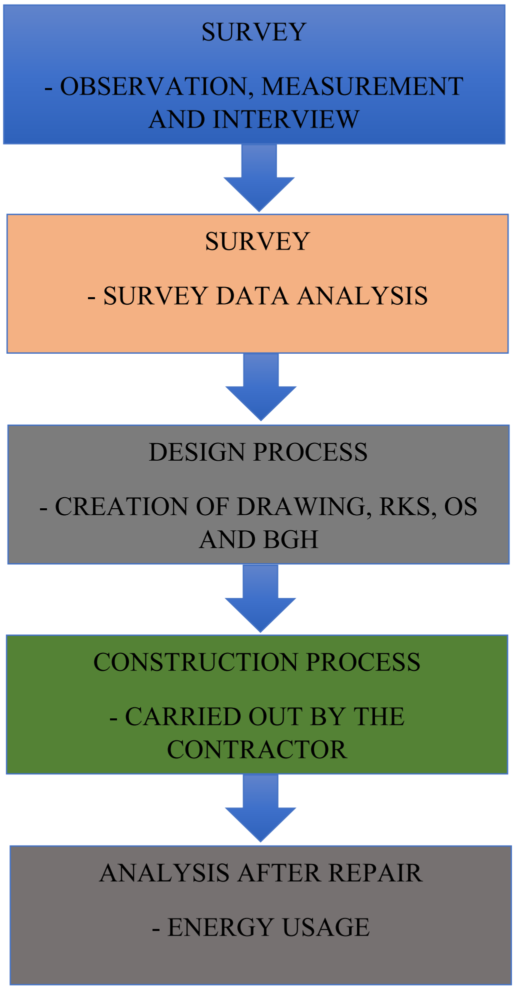


Figure 1. Research Methodology Stages

RESULT AND DISCUSSION

This discussion stage can be divided into 3 processes, namely the design process, BGH implementation, and result analysis.

Figure. 2. Discussion Stages

1. Design Process

Calculation Process

This calculation refers to theoretical foundations as well as the applicable standards or regulations in Indonesia. A basis for calculation is necessary so that the resulting design has effective and efficient capacity, neither insufficient nor excessive.

The design calculations for electrical distribution in the stadium are as follows:

a. Electrical Power Calculation (PDL)

Electrical power calculation is the calculation of the amount of power required to meet the installed loads of the building. PDL is needed to determine the connected PLN power, transformer capacity, generator capacity, capacitor bank capacity, etc.

The calculation results are as follows:

Non-Event Load

1. Main Power Load Requirement (PLN) : 717 kVA
2. Backup Power Load Requirement (GENSET) :408 kVA (Backup 52%)
3. Emergency Power Load Requirement (EMERGENCY) : 168 kVA

Event Load

Main Power Load Requirement (PLN): 553 kVA

Backup Power Load Requirement (GENSET): 553 kVA

b. Current Carrying Capacity (KHA)

Calculation Current Carrying capacity calculation is intended to calculate the design current by considering correction factors for cable installation, working environment temperature factors, and derating factors for multi-circuit installation. The current carrying capacity of a cable is as follows:

KHA of the conductor from TRAFO (KWH) to PDTR: 1,588 A (minimum KHA) Applied Busduct = CU 1,600 Amperes (R,S,T) + 2,500 Amperes (Neutral), and 1.50 cable R,S,T

c. Voltage drop

Voltage drop calculation is intended to obtain the percentage of voltage drop between the power supplier termination (panel) and the load termination (panel) connected by cable or other conductors.

Voltage drop is calculated from the farthest distance from the source to the equipment, where the farthest distance is SDP (Sub Distribution Panel) B from PDTR (Low Voltage Distribution Panel): Maximum Current (I) = 62.83 Ad.

d. Short Circuit Current Calculation

The short circuit current to be determined includes the upstream network, the termination of the Low Voltage Distribution Panel (PDTR), and several load panel terminations. The calculation used employs the MVA method.

- MVAsc Transformator Capacity = 1 MVA

Zsc = 4,5 %

MVAsc2 = (1 x 100) / 4,5

= **22,22 MVA**

e. Lightning Protection Calculation

The ground strike density (Ng) expressed in strikes to the ground per square kilometer per year should ideally be determined through measurements. If not available, it can be estimated using the formula (SNI 03-7015-2004 point 4.2).

The lightning conductor uses Copper (Cu): 23.77 mm²

f. Capacitor Bank Calculation

QC = 337 Kvar ≈ 350 kVAR

design drawing process

The process of creating planning drawings begins with the creation of system drawings, installation drawings, and detailed installation drawings.

a. Distribution System Drawing

Figure 3 is a single-line drawing that depicts the overall electrical distribution system of the stadium building from the PLN and generator power sources to the distribution panels (PP panels).

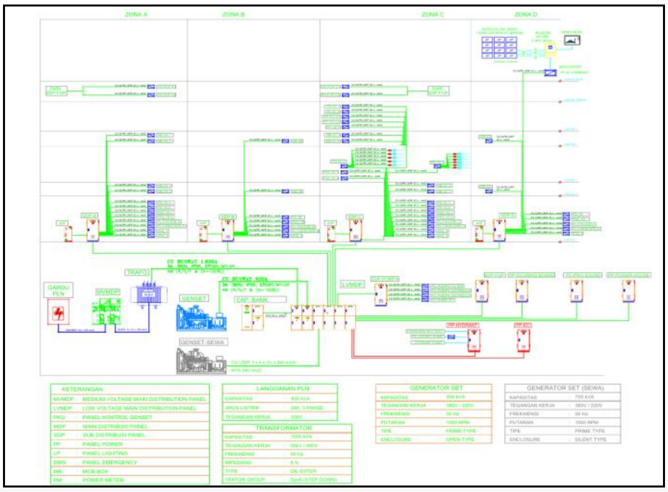


Figure 3. Single Line Stadium Electrical Distribution System

b. Electrical Outlet Installation

Figure 4 illustrates the locations of the panels, cable tray routes, and also the electrical outlet points in the stadium building.

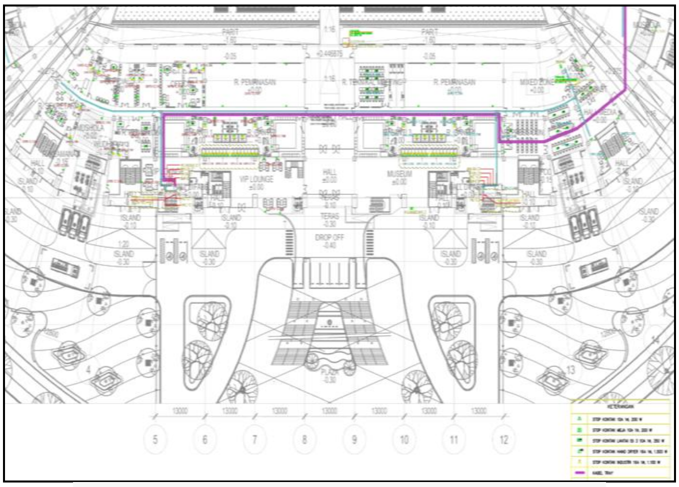


Figure 4. Drawing of Power Outlet Installation

c. Standard Detail Drawing

Figure 5 is a standard drawing of general electrical equipment, such as panels, cable trays, cable placement, lamp installation, socket installation, etc.

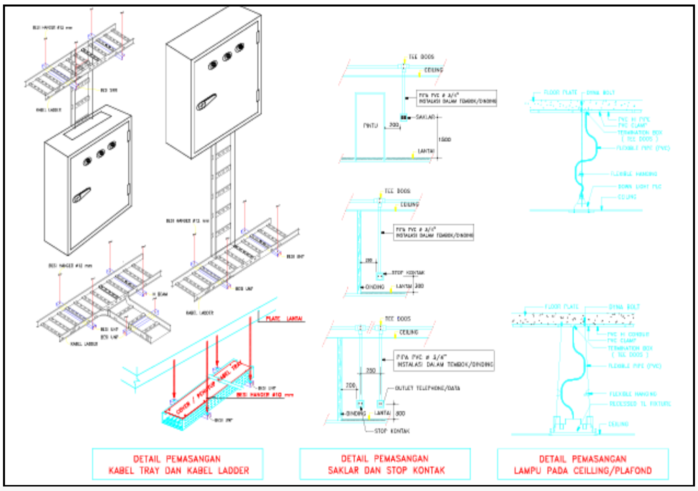


Figure 5. Detailed Drawing of Panel Installation, Cable Tray, and Lights

RKS and OS

a. Work Plan and Specifications (RKS)

RKS is the method and technical requirements that must be followed by contractors in carrying out construction work. RKS includes regulations and guidelines for carrying out work, work execution processes, test commissioning, testing, and permitting – permits that need to be managed, handover processes, etc.

As for the matters regulated in the RKS, they are as follows: Installation Work, Special Technical Requirements Medium Voltage, Special Technical Requirements Low Voltage, special Technical Requirements for Lightning Protection, Special Technical Requirements for Generator Set

b. Outline Specification (OS)

Outline Specification or technical specification is a crucial part of the planning document to ensure that the materials or components installed are as expected during the planning phase. The OS consists of detailed technical specifications for each component, as well as the recommended brand/brand of components.

Contractors or construction implementers are not allowed to deviate from the specifications and brands listed in the OS. If there are challenges during implementation, such as site conditions or procurement timing issues, the implementer may make substitutions, provided they are accompanied by technical justifications approved by the planner and the owner.

2. Implementation of the BGH Concept

Green Buildings, hereinafter abbreviated as BGH, are buildings that meet the Technical Building Standards and have significantly measurable performance in saving energy, water, and other resources through the application of BGH principles according to their function and classification at each stage of implementation. Green Buildings can be new or existing buildings that are planned for construction and operation while considering environmental sustainability factors.

BGH Categories and Parameters

According to Regulation 21 of 2021, in the technical planning stage of this building, the performance assessment at the technical planning stage consists of the following parameters: a. site management; b. energy use efficiency; c. water use efficiency; d. indoor air quality; e. use of environmentally friendly materials; f. waste management; and g. wastewater management. In this discussion, the categories and assessment parameters of BGH point (b) on electricity use efficiency will be explained. In the technical planning stage of this building, the performance assessment at the stage of electricity use efficiency parameters consists of the following criteria: a. Building Envelope; b. Ventilation System; c. Air Conditioning System; d. Lighting System; e. Indoor Transportation System; f. Energy Efficiency Calculation; and g. Electrical System;

BGH Performance Assessment Planning Stage

The achievement of the green building performance assessment (BGH) for this building is in the recommended category, in accordance with Government Regulation (PP) No. 21 of 2021, and it is mandatory because it is a state building (BGN) with an area of more than 5,000 m2, as stipulated in Government Regulation No. 16 of 2021. BGH ranking is carried out to determine the BGH rating, which consists of: a. Pratama BGH; b. Madya BGH; and c. Utama BGH The target for the green building performance assessment (BGH) for this building is the PRATAMA category.

BGH Performance Assessment Energy Efficiency Points

In the energy efficiency points section, systems other than electrical will also be explained, as they will also affect electricity usage in the end.

Table 1. Energy Efficiency Achievement Targets

NO.	CRITERIA	AVAILABLE POINT	ACHIEVEMEN T POINT
1	BUILDING ENVELOPE	9	9
2	VENTILATION SYSTEM	3	3
3	AIR CONDITION SYSTEM	7	7
4	LIGHTING SYSTEM	12	2
5	INDOOR TRANSPORTATION SYSTEM	3	2
6	ENERGY EFFICIENCY CALCULATION	5	5
7	ELECTRICAL SYSTEM	7	5
TOTAL		**46**	**33**

Building Envelope

a) OTTV and RTTV

The building envelope has accumulated values for Overall Thermal Transfer Value (OTTV) and Roof Thermal Transfer Value (RTTV). The available points are 5 and the points to be achieved are 5. OTTV and RTTV values affect the amount of area that utilizes natural lighting, thereby reducing electricity usage for artificial air conditioning systems (AC). If the building is planned not to use an air conditioning system, it will receive full points.

b) WWR (Window to Wall Ratio)

The ratio of transparent building envelope to solid building envelope or Window to Wall Ratio (WWR) is less than 30%, with available points being 4 and the target points to be achieved being 4. The WWR value will affect the amount of area that utilizes natural lighting, thereby reducing energy usage for artificial lighting systems (lamps).

Ventilation System

Buildings with rooms equipped with air conditioning systems, but planned not to condition some or all passive spaces (corridors, lift lobbies, toilets, etc.) and equipped with natural or mechanical ventilation to still meet thermal comfort.

Air Conditioning System

Planned to use Air Conditioning (AC) with the lowest room temperature of 25 degrees ± 1 and3.3. Electricity Usage Cost Analysis Relative humidity 60% ± 10%. Available points 2. and achievement assessment 2. Comparison of electrical power and AC capacity (KW/TR) or COP of air conditioning equipment in accordance with SNI 6390:2020 or the latest edition. Available points 5 and target achievement 5.

Lighting System

Artificial lighting meets the requirements (there is 1 switch in rooms smaller than 30 m²). Available points 2. Achievement assessment 0. Air lighting meets the requirements (use of occupancy sensors / lighting controllers in rooms with specific functions as required in SNI 6197:2020 or the latest edition). Natural lighting system meets the requirements (areas receiving natural lighting according to the standard, with separate lamp grouping from areas without natural light). Available points 4, achievement score 0.

Indoor Transportation System

If the building uses a vertical transportation system that has energy-saving features. For vertical transportation, elevators use Variable Voltage Variable Frequency (VVVF) technology. Available points: 1, points achieved: 1.

Energy Efficiency Calculation

There is a plan to save electricity consumption by calculating electricity usage lower than the baseline (W/m²). For every 2% savings in electricity consumption, 1 point is awarded, with a maximum of 5 points. Points achieved: 5.

Electrical System

The building is planned to have a grouping of electrical loads, each with a kWh meter, and sub-metering for electrical energy available for main power sources greater than 100 kVA. Available points: 2, assessment: 0 points. Buildings with a centralized air conditioning system must use a Building Management System (BMS) to control electricity consumption in the building. Available points are 3 points, achievement assessment is 3 points. There is a plan to utilize electricity from renewable energy sources. Available points are 2 points, achievement assessment is 2 points.

3. Analysis of Electricity Usage Costs

The analysis of electricity usage costs is obtained from electricity usage data before and after improvements by implementing the Green Building concept (BGH).

Analysis of Electricity Power Before Improvement

The electrical parameters measured on the Power Meter in the LVMDP panel are illustrating electricity power usage during peak load before improvement.

Fig. 6 

Fig.7

Figure 6. Maximum Power Usage Data Before Repair,
Figure 7. Maximum Power Usage Data After Repairs

From the following data was obtained: Average 3-phase voltage: 434.51 V, Average 1-phase voltage: 255.77 V, Average maximum current: 1,392.4 A, Maximum active power: 826.71 kW

Cost Calculation Analysis

For the analysis of the monthly electricity payment calculation, the data is as follows: P = 826.71 kW, Q= 640.697 kVAR, cos Ø= 0,79, T = 4 hours x 4 days (assuming 4 matches per week) = 16 hours. The electricity payment cost is based on the latest PLN data for 2025.Cost per kWh = Rp. 1,115 Cost per kVArh = Rp. 1,200. So, PLN kWh payment for 1 month is 826.71 kW x 16 hours x Rp. 1,115 = Rp. 14,748,506.00PLN kVARh payment for 1 month is 640.697 kVAR x 16 hours x Rp. 1,200 = Rp. 12,301,382.00. Total Payment = Rp. 14,748,506.00 + Rp. 12,301,382.00 = Rp. 27,049,888.00

Analysis of Electric Power After Improvement

The electrical parameters measured on the Power Meter in the LVMDP panel are illustrating the electricity usage during peak load after the improvement. The electrical parameters measured on the Power Meter in the LVMDP panel are illustrating the electricity usage during peak load after repairs.

The following data was obtained: Average 3-phase voltage: 431.45V. Average single-phase voltage: 248.10V, Average maximum current: 531.5A, Maximum active power: 370.43 kW.

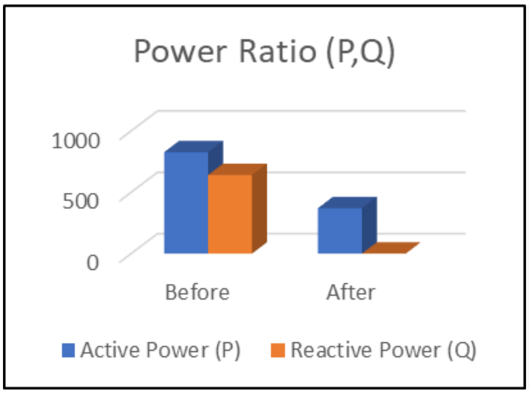
Cost Calculation Analysis

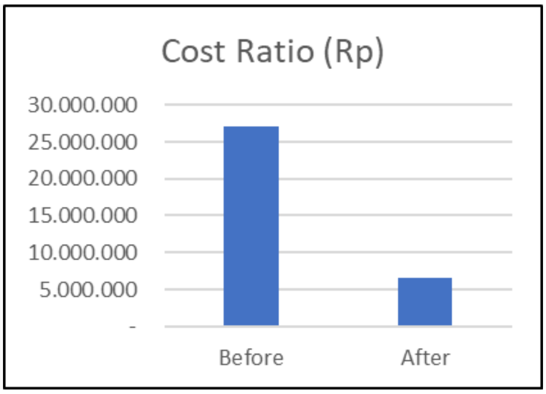
The analysis of the monthly electricity payment cost calculation is as follows: P = 370.43 kW, Q = 0 kVAR (power factor above 0.85), cos Ø = 0.93, t = 4 hours x 4 days (assuming 4 matches in a week) = 16 hours, Cost per kWh = Rp. 1,115Cost per kVArh = Rp. 1,200.

Thus, PLN kWh payment for 1 month is 370.43 kW x 16 hours x Rp. 1,115 = Rp. 6,608,471.00, PLN kVArh payment for 1 month is 0 kVAR x 16 hours x Rp. 1,200 = Rp. Total Payment = Rp. 6,608,471.00 + Rp. 0 = Rp. 6,608,471.00

Table 2. Comparison of Energy Usage Before and After Improvement

Parameter	Before	After	Difference
Active Power (P)	826,71 kW	370,43 kW	456,28 kW
Reactive Power (Q)	640,697 kVAR	0 kVAR	640,697 kVAR
Cost (Rp)	27.049.888	6.608.471	20.441.417





CONCLUSION

From the discussion above, it can be concluded as follows:

1. The electrical distribution system planning design at Patriot Candrabhaga Stadium needs to consider the theoretical basis, applicable standards, and regulations. It is expected that the planning design will produce a system that can function properly and efficiently and can pass the PBG (Building Permit) or SLF (Certificate of Proper Function) licensing process. The theoretical basis that must be mastered includes electrical power calculations, KHA, voltage drop, light intensity, capacitor bank capacity, and lightning protection. The standards referred to are the latest standards from SNI, PUIL, SPLN, or international standards such as IEC. The regulations referred to are the most current and applicable ones from PP, PERMEN PU, PERMEN ESDM, PERMENKES, and others.
2. From the data on electricity usage before and after improvements by implementing the Green Building (BGH) concept, a decrease in electricity consumption can be seen, which will automatically reduce Overall operational costs. The electricity usage cost before the repairs was 13,227.36 kWh + 10,251.15 kVAR = IDR 27,049,888.00, and the electricity usage cost after the repairs was 5,926.85 kWh + 0 kVAR = IDR 6,608,471.00. There is an electricity consumption saving of 7,300.51 kWh + 10,251.15 kVAR = IDR 20,441,417.00 within 1 month.
3. The implementation of the BGH concept at Patriot Candrabhaga Stadium with the primary target can create an environmentally friendly system, make energy consumption 55% more efficient for kWh payments, and 100% savings for kVARh payments, while contributing to the government's efforts in developing renewable electrical energy sources.

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Peraturan Pemerintah No. 16 Tahun 2021, mengatur bangunan yang wajib memiliki sertifikasi Bangunan Gedung Hijau

Peraturan Menteri Pekerjaan Umum dan Perumahan Rakyat Nomor 21 Tahun 2021 tentang Penilaian Kinerja Bangunan Gedung Hijau.

Peraturan Menteri Energi dan Sumber Daya Mineral Republik Indonesia No. 26 Tahun 2021 tentang Pembangkit Listrik Tenaga Surya Atap yang Terhubung Pada Jaringan Tenaga Listrik Pemegang Izin Usaha Penyediaan Tenaga Listrik untuk Kepentingan Umum