Development of green building maintenance information system for electrical components based on ministerial regulation

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Abstract. Green building maintenance is a series of structured, complicated and complex work. Maintenance of building components can support the achievement of building reliability requirements, which are safety, comfort, health and convenience. If this maintenance work is not done properly, it will cause problems and damages, such as trip, corrosion, overheated, electrical short circuit to building fires. This research aims to improve the maintenance performance of green building electrical components in order to achieve building reliability requirements by developing an information system. The research methods used are a systematic literature study of major academic and research papers and a case study of information system development in a green building to achieve the aim of this research. The result of this research is a web-based information system consists of guidelines for electrical components maintenance. This guideline informs about damages, damage categories, causes of damages, activities and schedule for each of electrical components maintenance in a green building. The result of this research revealed that green building maintenance guideline in a web-based information system will help to reduce the problems and damages that often occur in electrical components, thereby reducing the harmful impacts that can occur in a green building and its surrounding environment.

1. Introduction
Almost every building is inseparable from defect or damage despite various preventive measures taken during the design and construction. There are those who prefer to build a new building to replace the abandoned buildings repair and maintenance. As a result, more and more buildings must be evacuated well ahead of time that should be. This means that the country has lost a part of the property that was built from a limited capital. Maintenance is an activity to conserve, preserve, manage and regulate buildings, facilities, equipment, services and its surrounding buildings to meet current standards, the usefulness and value of defence facilities and security of the institution. Building maintenance is required once the building is complete [1]. The main aim of maintenance is to protect a building at its preliminary stage and to retain the value of investments in the property. Keeping a building in a condition in which it continues to fulfil its purpose and making sure it presents an attractive exterior are also important factors made possible through proper building maintenance. Building maintenance is an expensive process both from financial aspects (operational costs, real estate management, administration, job with debtors, legal services, etc.) and environmental aspects (climate change, greenhouse emissions, and energy efficiency measures) [2].
The purpose of green buildings is to increase the comfort and satisfaction of building occupants, while decreasing the negative impacts on environment, leading to reduction in costs. Green building practices provide a high level of supporting environment, increasing efficiency in the usage of various energy resources such as electricity, water, and environmentally friendly materials, and decreasing negative impacts on human health and environment during its life cycle [3]. Building maintenance activities have become more complex recently as they have evolved to be more sophisticated in design and functionality. The technology improvement in the building maintenance management system has been rapidly upgraded. Technology and device development plus the availability of integration with the system make it easier for the developer to ensure that they really are on the right current track. The process of developing technology is likely to be on-going as the building and its facilities become more sophisticated over the years [4].

In Indonesia, building maintenance is regulated in the Minister of Public Works regulation concerning building maintenance guidelines. But currently in Indonesia there is no regulations regarding green building maintenance guidelines. So, this research is aimed to provide a guideline for electrical components maintenance of a green building in a web-based information system. Electrical system requirements must pay attention to electrical installation planning, electricity distribution network, electricity load, electricity power source, distribution transformer, inspection, testing and maintenance. This guideline is expected to meet the needs of a green building that are guaranteed the aspects of human safety from electrical hazards, the safety of electrical installations and their equipment, the safety of green buildings and their contents from the dangers of fire due to electricity, and environmental protection.

2. Methods
The research methods adopted for this study are a systematic literature study and case study of information systems development. This research consists of five stages of data collecting and data analysing. Method of data collection was through questionnaire. The population of this study comprised the green building expert and green building maintenance expert. The first stage of data collection and analysis is to carry out identification and validation of green building electrical components based on ministerial regulation. The second stage is to identify and validate the green building electrical component damages and its category. The third stage is to identify and validate the causes of damage. The fourth stage is to identify and validate the maintenance activities and schedules based on ministerial regulation. The last stage of this research is the development of web-based information systems based on the results of data analysis that has been done in the previous stage. The process of developing this information system is carried out through several processes, including analysis and development of information systems, design, construction and testing. After the information system is completed, the final expert validation is carried out which aims to validate the information system that has been developed.

3. Results and discussion
Based on the data collection and analysing from stage one to stage three, a guideline about green building electrical components regarding damages, category and causes is shown in Table 1 below.
Table 1. List of green building electrical components, damages, category and causes.

| Electrical Component | Damages       | Category of Damage | Causes of Damage                      |
|----------------------|---------------|--------------------|---------------------------------------|
| Transformer          | Trip          | Medium             | Overload, overheat                     |
|                      | Oil spill     | Medium             | Broken rubber / adhesive              |
|                      | Corrosion     | Medium             | Weather and location                  |
| Transformer          | Broken insulation | Heavy            | Struck by lightning                    |
|                      | Dirty         | Light              | Lack of maintenance                   |
|                      | Short-circuit | Heavy              | Incorrect installation, overload      |
| UPS                  | Unable to supply power | Heavy | Low battery, lost power supply from main power |
|                      | Battery drop  | Heavy              | Duration of use                       |
|                      | Power drop    | Heavy              | Lost power supply from main power, duration of use |
|                      | Short-circuit | Heavy              | Incorrect installation                |
|                      | Overheat      | Medium             | Cooling system error                  |
| MVDP                 | Breaker off   | Medium             | Ampere adjustment error               |
|                      | Incorrect relay | Heavy            | Change of substation setting          |
| LMVDP                | Trip MCB and MCCB | Medium | Overload                              |
|                      | Lamp indicator off | Medium | Broken fuse                           |
| Panel Board          | Dirty and dusty | Light            | Lack of maintenance                   |
|                      | Corrosion     | Light              | Weather and location                  |
| Metering             | Error reading | Medium             | Duration of use, lack of calibration, fabrication defect |
|                      | Metering off  | Medium             | Incorrect installation                |
| MCB and MCBB         | Trip          | Heavy              | Overload                              |
| Lighting System      | Lights off    | Light              | Duration of use, lack of maintenance, incorrect installation, unstable voltage |
|                      | Lights dim    | Light              | Duration of use, lack of maintenance, deceased ballast power |
| Lighting Control System | Defunct control system | Medium | Incorrect setting                     |
|                      | Broken censor | Medium             | Lack of maintenance                   |
|                      | Error reading | Heavy              | Incorrect installation                |
|                      | Broken wire   | Light              | Lack of maintenance                   |
| Electrical           | Electric socket off | Light            | Broken wire                           |
| Socket and Switch    | Weak switch   | Light              | Lack of maintenance                   |
| Internet Network     | Short-circuit | Medium             | Overload                              |
|                      | Internet network off | Light | Overcapacity, network provider interruption |
| BAS                  | Error indicator reading | Heavy | Incorrect setting, lack of maintenance |

The result above shows the factors that influence building maintenance such as design factors, human factors, environmental factors, age of property or building, quality and appropriateness of material used, faulty construction and faulty system [5]. Based on the data collection and analysing from stage four, a guideline about maintenance activities and schedule for green building electrical components is shown in Table 2 below.

Table 2. Green building electrical components maintenance activities and schedule.
| Electrical Components | Maintenance Activities | Maintenance Schedule |
|-----------------------|------------------------|----------------------|
| Transformer           | Check and adjust the temperature and air condition in the transformer room, check the transformer oil. Clean the outside parts of the transformer. Check the cable connections at the bushing terminal, ground system, the condition of safety relay, bushing, terminal, seat, temperature and physical condition of transformer. Check security and measurement equipment. Check the high temperature alarm for each transformer. | Daily Weekly Monthly Monthly Monthly |
| UPS                   | Check and verify the condition of the cable, fuse, relay, battery back-up conditions and battery terminals. Check the UPS control system function and clean the terminal. Calibrate the pointing device on the UPS panel. Tighten every bolt. | Monthly Every 3 months Every 3 months |
| MVDP                  | Measure ground resistance. Check MV panel components (Load Break Switches, Earthing Switches, HRC Fuse, Lightning Arrester, Interlock System, measurement equipment and all the assist equipment). Clean the earth electrodes. Measure and clean the LBS contact resistance and Earthing Switch. Tests the electrical and mechanical interlocking. | Monthly Every 3 months Every 3 months |
| LMVDP                 | Check the LVDP panel status, current, voltage indication and KWH panel indication. Check the connecting indication on the power breaker. Calibrate all gauges on the panel. | Daily Monthly |
| Panel Board           | Check and clean the panel board. Check and improve the physical condition of the feeder cable and control cable. Check and tighten cable terminals, nuts and bolts. Tidy up the cable paths on the panel. | Monthly Monthly Monthly Every 6 months |
| Metering              | Check the recording of all measuring instruments, as well as evaluating and handling the results of the recording. Check the recording and accounting of the electric load curves from transformer output, and evaluating and handling the results of recording. Check and tighten the cable terminal to the meter. Calibrate all gauges on the panel. | Monthly Every 3 months Every year |
| MCB and MCBB          | Check the physical condition and cleanse water, moisture, dust and dirt on MCB and MCCB. Test the MCB and MCCB trips using Current Injector. | Monthly Every 3 months |
| Lighting System       | Observe every light point and the intensity of lighting Check the main switch status indication on each floor. Check the condition of battery back-up on emergency lights and clean the armature. Check the connecting indication on the power breaker and the operation of the main switch on each floor. Replace the battery back-up on the emergency lights. Test the insulation with Megger 500 V. | Daily Monthly Every 6 months Every 6 months |
| Lighting Control      | Check and observe all light points and the operation of the main switch on each floor centrally. | Daily Every 6 months |
| Electric Socket and Switch | Check the lighting and power supply contacts. Check the overall condition of the control system (transmission, terminals, transformers, relays, contact outputs, installation and equipment assistance). Clean the entire control system. | Daily Monthly Monthly |
| Electric Socket and  | Check and observe the function of all sockets and switches. Check the physical condition of the socket and switch, including the cord. Check the installation with Megger 500 V. | Monthly Monthly Every 6 months |
| Switch                 | Check the performance of Computer Networks, Servers, Repeaters, Hubs, and Uninterrupted Power Supply (UPS) equipment from the control panel in the operator's station. | Monthly |
| BAS                   | Check the conditions and indicators of all Building Automation System | Daily |
Table 2 above show maintenance activities and schedule for each of green building electrical components to reduce or avoid damages that often occur on components. This result can be a guideline in conducted maintenance for green building electrical components.

The next stage is developing a web-based information system based on the guideline that has been validated by green building experts. This information system provides all the information concerning all the objectives of this research. Figure 1 below shows the login page of this information system.

![Figure 1. Information system login page.](image1)

Figure 1 show the information system login page which can be accessed by the green building user and building management team. This system can be used to seek information regarding maintenance activities and schedule for each of green building electrical components. This system also functioning as a reporting system to report any damages occurred in green building so that the building management team take action to resolve the problems and also to make an appointment about periodic maintenance of each building components based on its schedule defined in Table 2.

![Figure 2. Information system dashboard.](image2)

Figure 2 show the dashboard of information system regarding all reports status. Every report will be documented on this system and can be used as a database for periodic reporting of building management team.
4. Conclusion
The development of a green building electrical components maintenance guideline in a web-based information system has shown its capability in improving maintenance work in achieving building reliability requirements. The information system will help to reduce the problems and damages that often occur in electrical components, thereby reducing the harmful impacts that can occur in a green building and its surrounding environment.

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