

Development of Maintenance-Repairment Guidance, and Material Specification for Green Building's Electrical Component in Government Building Based on Work Breakdown Structure (WBS)

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Abstract. Initial quality of building depends on quality of design and construction phase of the building, while maintenance and spare part quality keep the decline of the quality during operational phase of building within level of service needed. Electrical aspect of building has an impact of the building's purpose, safety, and comfort. Several findings in operation phase have been found regarding lack of quality of electrical maintenance process and spare part material such as fire incident, waste of electricity and excessive stock of spare part. Thus, it's important to not only develop maintenance and repairment guidelines of electrical work but also its material specification to keep the required level of service. The purpose of this study is to use work breakdown structure (WBS) methods as a proven method in decomposition to develop maintenance and repairment guidelines, as well as the material specifications in green building. The research methodology covers several stages: literature studies, information from previous projects, and delphi techniques through expert validation in green building electrical components. The results of this study are expected to create applicable guidelines for maintenance and repairment work of electrical component and its material specification to eliminate or decrease finding of electrical issues in building operational.

1. Introduction

According to Indonesia Centre Bureau of Statistic, the estimated value of construction works of the completed buildings is more than Rp. 206 Trillion in 2017. The value contributes almost 30% of the total construction industry in Indonesia (Rp 696T) and 1.7% of the total value of Gross Domestic Product (Rp 12.406T). The vast amount of the value demands high quality and level of service to the occupant.

Development of the building shall comply with government regulation such as Regulation of Public Works dan Housing Minister (PUPR) No 02/PRT/M/2015 and Jakarta Governor Regulation No 38/2012 that expressed its importance of green building method in design, construction and operational phase of the building. In addition to the regulation, green building method not only gives benefit to occupant's productivity and health [1], comfort and satisfaction [2], but also to the building owner and management in the form of lower operational and energy cost and effective energy utilization [3].



Application of green building by various independent certifications are based on criteria such as Site, Energy, Water, Indoor Environmental Quality (IEQ), Material, Waste & Pollution, and Management, with the most influential criteria on the assessment is the energy aspect[4]. Electrical as the most common energy use in building should have biggest impact on Green Building application. Miss management of the electrical could leads to building incident such as in efficient use of electricity [5], short circuit or fire [6], and spare part overstock [7].

These electrical impacts of building raise the needs of proper maintenance and material specification to make sure quality of the building. Designers / Engineers play an important role to produce designs with good quality and constructability [8]. The maintenance guideline and material specification reduce dependence on personal in order to keep quality of the building as per required in every phase of maintenance of building.

The scope of this study are limited to the following : (1) standardized WBS for electrical aspect in the building, (2) standardized electrical material specification, and (3) the research conducted on green building project in government building.

2. Research objectives

The objectives of this research are :

1. To identify the type and work package for maintenance and reparation in government green building
2. To identify alternative design, activity, implementation requirement, and resources for government green building maintenance and reparation
3. To determine material specification
4. To develop guideline for maintenance and reparation of electrical aspect

3. Literature review

3.1. Government buildings

According to Minister of Public Works Regulation no. 45 Year 2007, Government Building is a building for the purposes of service that becomes / will become state-owned property such as office buildings, school buildings, hospital buildings, warehouses, and country houses, and held with financing sources derived from state budget funds, and / or other legitimate acquisitions.

3.2. Green building

According to Regulation of Public Works and Housing Minister (PUPR) No.2 year 2015 on green building, green building is a building that fulfills the building requirement and has significantly measured performance in energy, water and other resource savings through application principles of green building according to function and classification in each stage of its implementation. There are national and international organizations that have own definition and criteria to certify a building as green building.

3.3. Work break down structure

Work Breakdown Structure (WBS) as a proven method to decomposed higher component to the smallest component is used to create the structured and completed guidelines. WBS is a structured decomposition of the overall scope of work that the project team must accomplish to accomplish the project objectives and complete the required results [9]. A complete and efficient WBS will be an important part of project management planning by dividing the project into multiple stages, deliverables and work packages [10]. There are several efforts to standardized WBS such as underground construction [10], apartment building [11], high rise building architectural works [12] and building safety plan [13]. This study will employ WBS method in maintenance and reparation works in government green building..

Proposed WBS stage / component in electrical maintenance and reparation works is shown in Figure 1.

3.4. Maintenance and reparation guidelines

Final goals of this study is applicable maintenance and reparation guidelines, which consist of alternative design in all work package, the activity that will be implemented in each equipment/alternative design, procedure and resources to complete the activity and material spesification for spare part or replacement unit.

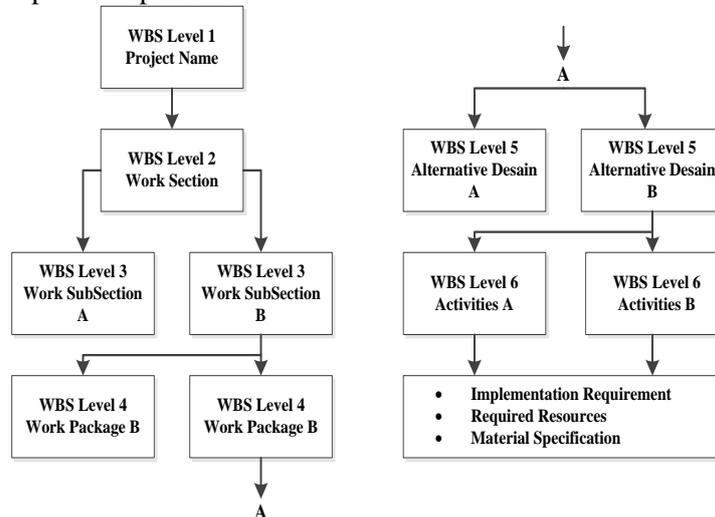


Figure 1. WBS diagram tree.

4. Research methodology

Qualitative research method is used in this study to get result in each research objective. (1) central and local government regulation, project archive, green building certification program reference and other journal or books are used to identify sub work section and work package, the the data are validated by expert using delphi method. (2) Further study literature is used to determine draft of alternative design, activity, implementation requirement, resources needed to completed maintenance and reparation of each work package, that draft shall be validated by the expert. (3) furthermore, material specification determined by literature studies, with government regulation, national standard, green building certification requirement, and past project experience take into consideration. Validation by expert conducted to compile the final material specification (4) previous result of research objective collected and documented as maintenance and reparation guideline, then final validation through experts use delphi method.

5. Results and discussion

WBS in figure 2 has been validated by expert, decomposed all required work package in maintenance and reparation of electrical work in government green building. One of differentiation between typical office building with green office building is renewable energy generation requirement in green building, this item can be found in the sub work section and work package.

The WBS divided by four sub work section, and twenty work packages. First sub work section is power sources as the system that generates power, or as receiver from grid system, consists of transformer, UPS, backup power generator, and renewable energy power generation work package. Second sub work section is distribution, as the system that transmit electrical form source to load, consist of medium voltage panel and LVMDB Panel work package.

Third sub work section is electrical load, consists electrical load panel, cable, lighting equipment, lighting control system, receptacle and switch, grounding system and lightning protection system work packages. Last sub work section is electronics consists of fire alarm and detectors, telephone, sound system, internet and computer, TV and CCTV, signal repeater and building automation system work packages.

Components of the building will be differing for each building depends of the design of the building. This study will present alternative design available for each package. One of the workpackage is shown below,

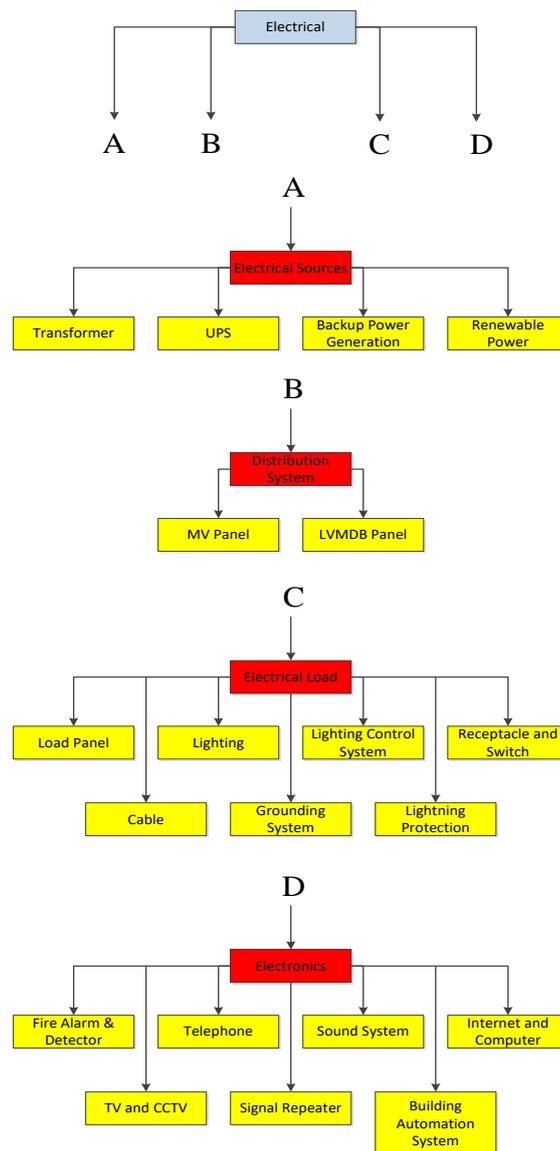


Figure 2. Electrical sub work section and workpackages.

Table 1. Alternative design of electrical works.

Work Package WBS Level 3	Alternatif Design WBS Level 4
Transformer	Dry Transformer
	Liquid Transformer
Uninterruptable Power Supply	Local UPS
	Central UPS
Backup Power Sources	Diesel Engine Generator
	Gas Engine Generator
Renewable Energy Sources	Solar Panel
	Ground Sources Heat Pump
	Wind Turbine
Medium Voltage Panel	Oil Circuit Breaker
	Vaccum Circuit Breaker
Low Voltage Main	Mechanical Circuit Breaker

Distribution Panel	Solid State Circuit Breaker
	Miniature Circuit Breaker
	Molded Case Circuit Breaker
Load Panel	Load Panel
Artificial Lighting	LED Lamp
	HID Lamp
	Fluorescent Lamp
Lighting Control System	Dimmer
	Lighting Sensor
	Time Sensor
Receptacle and Switch	Receptacle
	Switch
Under Floor Duct / Raised Floor	Under Floor Duct
	Raised Floor System
Cable	High Voltage Cable
	Medium Voltage Cable
	Low Voltage Cable
Grounding System	Solid Grounding
	Resistor Grounding
	Ungrounding
Lightning Protection	Lightning Rod
	Lightning Rod - Tight Wire
	Lightning Rod - Meshed Cage
Fire System and Detector	Smoke Detector
	Heat Detector
	Fire Panel
	Fire Alarm
Telephone	Telephone
Sound System	Sound System
Internet and Computer System	Ethernet Cable
	Wifi
TV dan CCTV	TV
	CCTV
Signal Repeater	Signal Repeater GSM
Building Automation System	Sensor
	Control Panel

This list of alternative design covered all possibility of work packages needed in electrical works are shown in Tabel 1. Each of alternative design will need a specific implementation requirement formed from action to be taken from each activity and resources to complete the activity.

Table 2 shows example of one alternative design including it's detail of activity and resources.

Table 2. Activity and resources of solar panel work packages

WBS Level 1 Maintenance & Reparation Works	
WBS Level 2 Electrical	
WBS Level 3 Power Source	
WBS Level 4 Renewable Energy Sources	
WBS Level 5 Solar Panel	
Inspection Activity	
-Voltage measurement in each solar panel, batere bank, rectifier	Resources: -Electrical Technician

-Visual inspection in present of dust, rust, and inclination of solar panel -Check tightness of bolt/nut -Check leak or damage in batere cell	-Multimeter -Torquemeter -Hand Tools
Maintenance Activity	
-Make sure area n devise is safe, if required use LOTO device -Clean solar cell from dust and rust -Fix inclination and solar panel position -Fix torque of bolt and nut -Check level of batere elektrolit	Resources: -Electrical Tecnician -Multimeter -Torquemeter -Hand Tools
Reparation Activity	
-Replace solar panel and panel that exceed lifetime or drop in efficiency -Replace electrical component that broken or obsolete -Fill up the batere electrolite	Resources: -Electrical Tecnician -LOTO -Multimeter -Torquemeter -Hand Tools -Batere Electrolite -Spare Part
Testing Activity	
-Test output voltage of the solar panel -Test grounding condition -Test cable insulation condition -Test electrical protection -Test batere system backup time	Resources: -Electrical Tecnician -LOTO -Multimeter -Insulation Tester -Hand Tools

Then, material specification for each altenative design shall be developed and validated by expert. Tabel 3 shows example of material specification proposed for solar panel

Table 3. Example of material specification

Solar Panel Material Specification
-Comply with SNI 04 3850.2 Tahun 1995 -Comply with latest Panduan Umum Instalasi Listrik – Government Regulation of General Guidance of Electrical Installation -Comply with ISO 14001 -Produce within 1000 KM radius from building site -Equiped with Power Management system software

All this material specification shall be valid for spare part and or unit replacement. Next result of this study is compilation of all previous objectives, Maintenance and Reparation Guidelines. Table 4 shows example of inspection part of maintenance and reparation guidelines of solar panel in green building. This guidelines validated by building owner and operator.

Table 4. Maintenance and reparation of solar panel

RENEWABLE ENERGY RESOURCES
Description : The document covers guideline for maintenance and reparation of renewable energy work packages including its alternative design which is
1.Solar Panel system;

2. Ground Sources Heat Pump system; 3. Wind Turbin system.	
The general requirement of the overall activity including -Use standard and special personal protective equipment; -Obtain permit and clearance; -Clear and secure area; -Risk assessment and mitigation	
SOLAR PANEL	
Section	Electrical Work
Sub-Section	Power Source
Work Packages	Renewable Power Source
Alternative Design	Solar Panel System
GUIDELINES	
Inspection	
This activities cover surveillance and monitoring of the device or system to find anomaly or defect during normal operation, without shutdown the system or device. The anomaly and defect shall be register and planned for next maintenance or reparation activity.	
Detail Procedure	Resources
1. Prepare documentation, permit, and drawing for the system 2. Prepare tools, personal safety equipment and access 3. Prepare barricade and signage 4. Check visual of each of system (Solar Panel, Cabling, Rectifier, Batere System and Distribution Panel) for dust, rust, defect and anomaly. 5. Check visual inclination of solar panel module 6. Check voltage and ampere of input-output of each module 7. Check torque of bolt (if possible) 8. Check Anomaly in batere system, if there are any leak, rust, or cracking	1. Engineering Drawing 2. Electrical Technician 3. Tools, Personal Safety Equipment 4. Barricade and Signage 5. Inclination Tools 6. Multimeter 7. Torque Meter
Material Specification	
1. Comply with SNI 04 3850.2 Tahun 1995 2. Comply with latest Panduan Umum Instalasi Listrik – Government Regulation of General Guidance of Electrical Installation 3. Comply with ISO 14001 4. Produce within 1000 KM radius from building site 5. Equiped with Power Management system software	

6. Conclusion

This compiled guideline of maintenance and reparation for government green building should help building owner or operator to maintain quality and level of service that tenant or occupant needed. There are others aspect of maintenance and reparation in building need such as architecture, interior, landscape, and mechanical that should have maintenance guidenence also. Further study should be consider to create maintenance standarized for non office building such as apartement and specialized building (airport, port, school library etc).

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