Civil Engineering and Architecture 12(2): 740-753, 2024
DOI: 10.13189/cea.2024.120207 http://www.hrpub.org

Development of Work Breakdown Structure (WBS) in High-Rise Office Buildings using Green Retrofitting based on GBCI and Minister of PUPR Regulation No. 21 of 2021 to Improve the Quality of Resource Planning

Bernadette Detty Kussumardianadewi[1,*], Yusuf Latief[1], Bambang Trigunarsyah[2], Ayomi Dita Rarasati[1], Winny Widiani[1]

[1]Department of Civil Engineering, University of Indonesia, Indonesia
[2]School of Property, Construction and Project Management, RMIT University, Australia

Received July 12, 2023; Revised October 30, 2023; Accepted November 20, 2023

Cite This Paper in the Following Citation Styles

(a): *[1] Bernadette Detty Kussumardianadewi, Yusuf Latief, Bambang Trigunarsyah, Ayomi Dita Rarasati, Winny Widiani , "Development of Work Breakdown Structure (WBS) in High-Rise Office Buildings using Green Retrofitting based on GBCI and Minister of PUPR Regulation No. 21 of 2021 to Improve the Quality of Resource Planning," Civil Engineering and Architecture, Vol. 12, No. 2, pp. 740 - 753, 2024. DOI: 10.13189/cea.2024.120207.*

(b): *Bernadette Detty Kussumardianadewi, Yusuf Latief, Bambang Trigunarsyah, Ayomi Dita Rarasati, Winny Widiani (2024). Development of Work Breakdown Structure (WBS) in High-Rise Office Buildings using Green Retrofitting based on GBCI and Minister of PUPR Regulation No. 21 of 2021 to Improve the Quality of Resource Planning. Civil Engineering and Architecture, 12(2), 740 - 753. DOI: 10.13189/cea.2024.120207.*

Abstract Buildings built before the 2000s are still vulnerable to exposure to the importance of energy efficiency, so renovations are needed on this existing building through renovation (green retrofitting) for sustainability goals that reduce energy expenditure. Modification is an effort to adjust the performance of built buildings to obtain a certificate as a green building. Both government and non-government agencies certify customization with different benchmarks/ parameters. In Indonesia, there are two regulations and benchmarks in the assessment of BGH performance, namely the Green Building Council Indonesia (GBCI) and PUPR Regulation Number 21 of 2021. The portion of existing high-rise office buildings is 98% of the total number of office buildings, which is very significant in achieving the government's target. The obstacle to implementing Green Retrofitting in High-Rise Office Buildings is the high cost. To be able to make green retrofitting costs efficient, researchers conducted a statistical analysis using the Relative Important Index (RII). The results of this study showed that the most influential factors at the planning stage were the energy-saving SOP document with an index of 0,996, the construction stage was Document on the implementation of ideas and innovations in construction methods with an index of 0,992, and the post-construction stage was Certificate of Expert Building Management Manager with an index of 0,998. The implementation of customization can be through the development of a Work Breakdown Structure (WBS), to detail the resources needed in project planning, monitoring, and control. The results of the study are proof that the WBS structure of customization work based on GBCI and PUPR Regulation Number 21 of 2021 affects improving the quality of resource planning using survey methods and literature studies.

Keywords Green Retrofitting, High-rise Office Buildings, WBS, Green-ship GBCI, PUPR Minister Regulation Number 21 of 2021

1. Introduction

The government supports national efforts in energy conservation at the scale of buildings, dwellings, and areas. Towards Net Zero Emissions from the building and construction sector is to reduce Greenhouse Gas (GHG) emissions, because buildings are the largest contributor to GHG.

Based on the target of zero-emission buildings by 2050, the implementation of green retrofitting in developed countries should increase to 2.5% by 2030. Due to the faster lifetime of buildings in developing countries, retrofit buildings in countries should grow by around 2% by 2030. By 2050, it is expected that more than 85% of all buildings have been retrofitted [1].

According to PUPR Ministerial Regulation No. 21 of 2021, Retrofitting is an effort to adjust the performance of buildings that have been utilized to meet the requirements of "Bangunan Gedung Hijau" (BGH). The urgency to do green retrofitting is supported because two-thirds of buildings in 2040 are in a state of development [2]. As seen in Figure 1, about half the number of buildings today will still survive until 2050 [1]; in addition, buildings built before the 2000s are still vulnerable to exposure to the importance of energy efficiency so renovations are needed on buildings that have been built through green retrofitting [3].

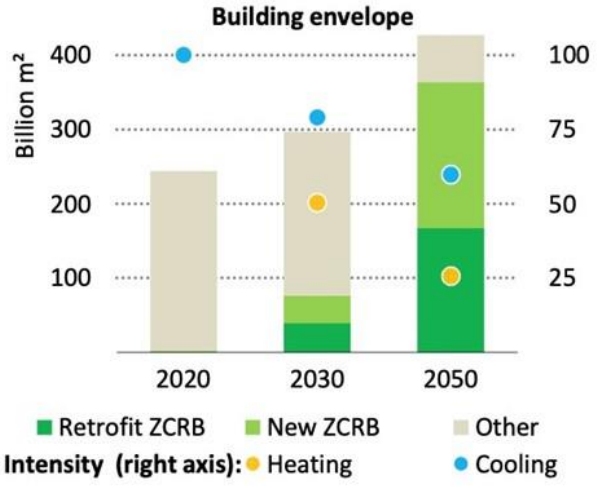

Figure 1. Target Net Zero Emission 2050 of Green Retrofitting

However, buildings built before the 2000s are still vulnerable to exposure to the importance of energy efficiency, so renovations are needed for buildings that have been built through green retrofitting [3]. According to PUPR Ministerial Regulation No. 21 of 2021, Retrofitting is an effort to adjust the performance of buildings that have been utilized to meet the requirements of Green Building Buildings (BGH). The urgency to do green retrofitting is supported because two-thirds of buildings by 2040 are in a state of development [2] and about half the number of buildings today will still survive until 2050 [1]. The Sustainable Development Agenda (SDGs) in 2030 is to declare a development shift towards sustainable development based on equality and human rights to promote social, economic, and environmental growth [4]. The majority of the reductions in heating and cooling energy intensity in the NZE may be attributed to improvements in building envelopes in zero-carbon ready retrofit and new construction, although heating and cooling technology also contributes significantly. Households heated by natural gas will make up less than 0.5% of all households in the NZE in 2050, while homes heated by electricity will make up almost 20% of all homes in the NZE now, 35% in 2030, and roughly 55% in 2050 [5].

1.1. Retrofitting Conditions in Indonesia

Building density in Jakarta causes the lack of possibility for the construction of a new building to be certified as a Green Building because the process is long and involves many stakeholders from the government to non-profit organizations. With these conditions, alternatives can be done with Green Retrofitting, which is the renovation or continuous improvement of a building that is already operating and utilized to improve the performance of the function of buildings that have been built in aspects of energy and environment, efficiency of water use, air quality and sound in whole or part that can minimize the adverse impact of the building on the environment.

The consequences of this activity are a relatively long time, large costs, and designs that must apply six aspects to customization, which is the reason for the lack of existing buildings to be green in Indonesia. Currently, only 22 Green Building Buildings are retrofitted by GBCI, 52 buildings are certified by EDGE, and only 2 buildings are certified Garuda by the Minister of PUPR Regulation No. 21 of 2021.

The impact of the small number of green buildings in Indonesia is that Indonesia is one of the contributors to the cause of climate change by producing CO_2 emissions. Decarbonization efforts are carried out by the State of Indonesia through Nationally Determined Contributions (NDC) by participating in the Paris Agreement approved by Indonesia in New York on April 22, 2016. The implementation of the Paris Agreement in Indonesia is strengthened by the Law of the Republic of Indonesia Number 16 of 2016 concerning the Ratification of the Paris Agreement to The United Nations Framework Convention on Climate Change. The Ministry of Energy and Mineral Resources has prepared various regulations, strategic plans, and actions to achieve the target of reducing emissions by 11% by 2030.

1.2. Regulation and Achievement Target

PUPR Minister Regulation Number 21 of 2021 regulates the Performance Assessment of Green Building Buildings stipulated on March 31, 2021, by the Ministry of Public Works and Public Housing. The Green Building Technical Standard Assessment is applied to new Buildings (with

mandatory and recommended categories), Existing Buildings (with required and recommended categories), H2M (with recommended categories), new Green Areas (with recommended categories), and existing Green Areas (with recommended categories). Green Retrofit in this regulation is interpreted as an adjustment. The maintenance stage of the modification evaluation includes utilization and demolition.

PUPR Ministerial Regulation Number 21 of 2021 concerning Green Building Performance Assessment was created to assist in the certification and implementation of green buildings in Indonesia, which replaced PUPR Ministerial Regulation Number 02/PRT/M/2015 concerning Green Building Buildings. Even though the rating tools have been released and published, infrastructure organizations still need to develop further to include criteria for increasing human capacity at the design and construction assessment stage [6].

The benchmarks are contained in PUPR Regulation Number 21 of 2021 for the performance assessment of Green Building for existing buildings, which is divided into two stages, namely the utilization stage with a total of 165 points which includes technical planning for retrofitting and retrofitting construction, and the demolition Stage which has a total of 165 points consisting of indicators of the demolition process and efforts to restore the environmental site.

In addition to regulations released by the government, there are also rating tools released by independent non-profit bodies established in 2009. GBCI rating tools and PUPR Minister Regulation Number 21 of 2021, both have benchmarks/assessments regarding existing buildings. The benchmark of rating tools published by Green Building Council Indonesia is contained in GREENSHIP Rating Tools Version 1.1 which has six aspects in its assessment, including Appropriate Site Development (ASD) which has an assessment weight of 13.68% with 2 prerequisite indicators and 7 main assessment indicators, then the Energy Efficiency And Conservation (EEC) aspect is weighted by 30.77% with 2 prerequisite indicators and 7 assessment indicators, then Water Conservation (WAC) with a weight of 17.09% which includes 1 prerequisite indicator and 8 assessment indicators, Material Resource And Cycle (MRC) aspects have prerequisites and 5 assessment indicators, then Indoor Health And Comfort (IHC) weighs 17.09% with 1 prerequisite indicator and 8 assessment indicators, and last is the Building Environment Management (BEM) aspect with a weight of 11.11% with 1 prerequisite indicator and 5 assessment indicators.

2. Study of Literature and Problems

2.1. Identify Problems (resources as obstacles)

Resources are an ability and capacity of retention that is utilized for human activities. Project resources consist of human resources, material resources, and equipment resources [7]. Resource planning is part of project resource management in PMBOK 6th edition. Based on the 6th edition of PMBOK, the project resource management process begins with a resource management plan. A resource management plan is a process of determining how to estimate, acquire, manage, and use project teams and resources. This process undertakes efforts to manage project resources based on project type and complexity. Resource planning is used to define and identify to ensure resource needs are met during the project.

The implementation of retrofitting can certainly cause problems with the safety of residents, expensive investment costs, and difficulties in licensing. A retrofit target of not reaching 2.5% by 2030 allows for the failure of the entire building to retrofit by 2050. In addition, the rollback of retrofit implementation based on the NZE target was able to increase demand for space heating by 25%, and demand for air conditioning by more than 20% so that electricity increases by 20% by 2050 [1].

People in other countries feel directly the benefits of implementing green building and retrofit, in the context of environmental impacts for example in Singapore factors that encourage its residents to implement green retrofit that is felt directly are mostly cost savings from lower electricity bills in the long-term, availability of financial assistance or green loans from the government, good impact on the environment, and higher resale value [8].

2.2. WBS as an Approach

WBS, as defined in the PMBOK Guide-Third Edition, is: "A results-oriented hierarchy of decomposition of the work to be carried out by the project team to achieve project objectives/ objectives and create the necessary results. Each declining level represents an increasingly detailed definition of project work". The definition of WBS per term can be described as follows [9].

Ease of implementation of green retrofitting or modification can be through the development of the WBS structure. Making WBS is a general work plan, and work implementation, which is useful for the completion of work, the basis for planning, and clarification of report and accountability procedures [10]. Based on the 6th edition of PMBOK, efforts to detail the resources needed for project planning, monitoring, and control can use Work Breakdown Structure and Resource Breakdown Structure.

For ease in implementing green retrofitting, it is done with the help of Work Breakdown Structure (WBS), which functions as minimizing the widening of project scope, ensuring the products produced follow requirements, reducing rework, and avoiding project cost and time overruns [11].

This research will develop a Work Breakdown Structure (WBS) structure from 6 aspects of green retrofitting work for high-rise office buildings based on GBCI and PUPR Minister Regulation Number 21 of 2021 to improve the quality of resources. The WBS level will reach an activity level that can be utilized by various institutions or agencies

that will carry out green retrofitting. This research has only been conducted and has never been studied by anyone before.

In project resource management, representing data is not just limited to diagrams. Regardless of the method used, the aim is to ensure that each work package remains clear. Formats in hierarchies can be used to represent high-level roles. One type of hierarchy is the Work Breakdown Structure (WBS) which is designed to show the results of work broken down into work packages and provides a way to show areas of high responsibility [9].

2.3. The Quality of Resource Planning

Construction project resources are potential capabilities and capacities utilized to carry out construction activities. Project resources consist of human resources, material resources, and tool resources [7]. According to PMBOK 6th Edition, resource planning management is one of the processes of project resource management. Resource planning management is the process of defining ways to estimate, acquire, manage, and use resources. The output of the resource planning process is a resource management plan that provides direction for how project resources need to be categorized, allocated, managed, and used. The resource management plan is then used to estimate activity resources on the project where the activities on the project can be identified through the creation of WBS [9].

3. Methodology

The research method used is through archival analysis, Delphi data analysis to green retrofitting experts using questionnaires, and descriptive analysis of expert answers. Delphi data analysis content and construct validation by experts using questionnaires, pilot surveys to respondents, data analysis using RII methods, and expert opinions on the final results of the study. The entire process of collecting and analyzing data will produce outputs in the form of WBS standards in GBCI-based green retrofitting work and PUPR Minister Regulation Number 21 of 2021 to improve the accuracy of resource planning and which assessment activities or benchmarks are important and affect the accuracy of resource planning.

3.1. Measured Variables

The types of variables used in this study are independent variables (variable X) which are variables that provide responsibility for changes or impacts on a phenomenon or situation and dependent variables (variable Y) which are variables that become results or changes given by independent variables [12].
The X and Y variables in this study are:

- Independent variable (X): WBS standard that has been integrated between GBCI's Green-ship Rating Tools Existing Building and BGH Performance Assessment Checklist for Existing Buildings from PUPR Regulation Number 21 of 2021, which is prepared by approaching the project cycle as shown in Tables 2,3,4,
- Dependent variable (Y): Resource Planning Accuracy as shown in Table 1.

Table 1. Dependent Variable (Y)

Main Factor		Sub-Factor	References
Y1	Human resources	Human resources manage the workforce/humans in a construction company to carry out work following their fields of knowledge so that the project can run according to plan.	[13],[14]
		A realistic number of project workers needs to pay attention to various factors, namely labor productivity, limited resources, the number of construction workers in the field, and the leveling of the number of workers to prevent sharp fluctuations	[13],[14]
Y2	Material resources	Material resources in construction projects are materials used to carry out construction project construction activities.	[13],[14]
		Some things to consider in the selection of building type and function materials are the needs of building owners, local regulations, location constraints, regulatory constraints, available funds, long-term wisdom in maintenance and adaptation, and minimum quality levels of materials	[13],[14]
Y3	Equipment Resources	Material resources in construction projects are materials used to carry out construction project construction activities.	[13],[14]
		Factors that influence the selection of equipment are functions that must be carried out such as equipment capacity, mode of operation, restrictions on the methods used, economy, type of project, project location, type of soil carrying capacity, and field conditions	[13],[14]

In this study, researchers used latent variables from variables Y1.1, Y1.2, and Y1.3 using the mean technique. The latent variable Y average is obtained by calculating the average of the answers from each respondent on variables Y1.1, Y1.2, and Y1.3. It is obtained that the average latent variable Y already has a sufficient number of samples, so for subsequent tests, the researcher will use the average latent variable Y as the dependent variable.

After the data for variables X and Y have been declared homogeneous and sufficient, the next test is internal validity testing using Kendall's Tau Correlation Test. Internal validity testing is performed on variable X only because variable Y will use the latent variable Y on average only. Variable data can be said to be valid if two variables X are interrelated or correlated.

3.2. Relation Model Variables and Research Indicators

The relationship between variables often known as the relationship between two variables, namely the independent variable (Independent/influence) with the dependent variable (Dependent/affected) with X and Y symbols is usually associated with the analysis of causal relationships. However, according to [15], the relationship between the independent variable and the dependent variable is not always causal. It is further emphasized that there are interrelated variables, but one variable does not affect the other variable.

This study will explain that the level of green retrofitting activity in the WBS structure will affect or relate to improving the quality of resource performance planning. Then the relationship between variables can be modeled as follows Figure 2.

The relationship and influence between variables can be seen in Figure 2. Variable X1 is the Planning Stage, Variable X2 is the Implementation Stage, and Variable X3 is the Post-Implementation Stage of the Main Factor which is Retrofitting Work. The derivative variables which are indicator indicators as components of activities to be measured level (index) are as follows (Tables 2, 3, 4).

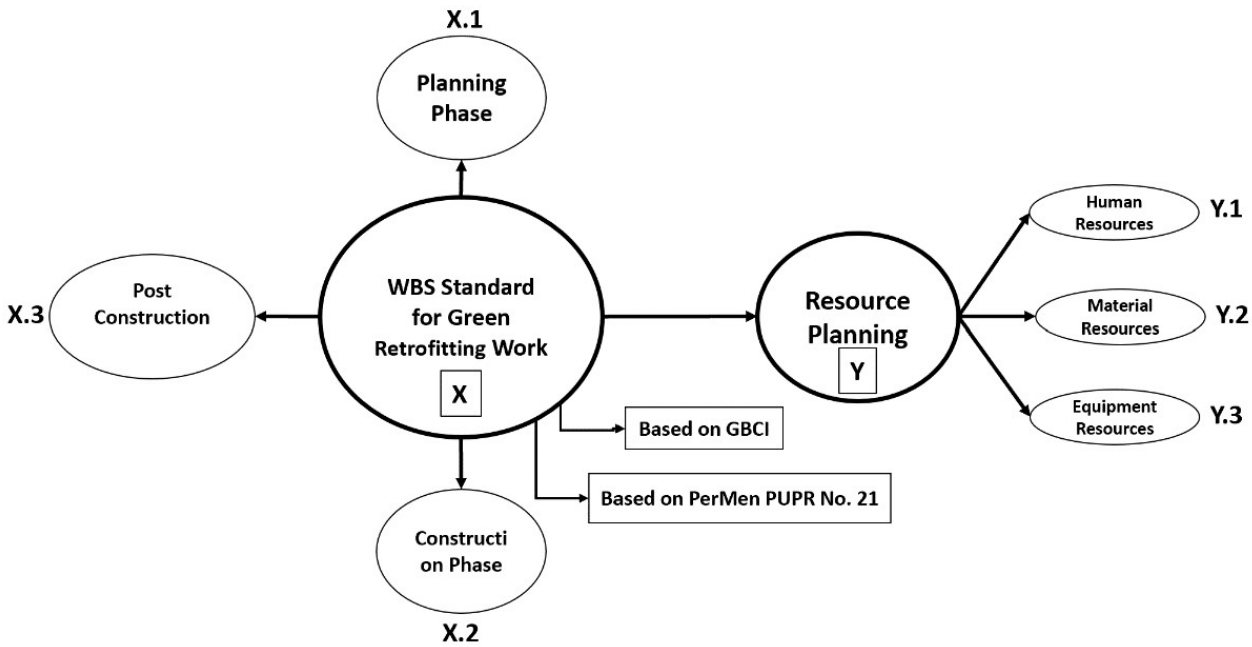

Figure 2. Research Operational Model

Table 2. Sub-Factors of Planning and Design Stage (X1)

	Sub-Factor	References	RII Index	Rank
X.1.1	User data documents, photos, receipts, and others.	[16],[17]	0,79	86
X.1.2	Energy saving SOP document	[16],[17]	0,996	1
X.1.3	ISO-14001-certified eco-friendly coating material	[16],[17]	0,97	8
X.1.4	ISO-14001-certified eco-friendly paper purchasing	[16],[17]	0,786	88
X.1.5	Reusable scrap distribution procedure document	[16],[17]	0,785	89
X.1.6	Documents on the use of cleaning agents	[16],[17]	0,88	42
X.1.7	The decree banning the use of plastic bags	[16],[17]	0,882	41
X.1.8	SOP document for water-saving efforts	[16],[17]	0,936	15
X.1.9	Commitment letter of smoke-free buildings.	[16],[17]	0,852	57
X.1.10	Building policy document.	[16],[17]	0,788	87
X.1.11	Building exterior maintenance management commitment	[18]	0,859	53
X.1.12	Management commitment letter to pests and weeds	[18]	0,857	54
X.1.13	Letter of commitment to Habitat management	[18]	0,865	50
X.1.14	Commitment letter reduction of private vehicle usage	[18]	0,855	55
X.1.15	Campaign to reduce the use of private vehicles	[18]	0,853	56
X.1.16	Policy evidence-reducing private vehicles	[16],[17]	0,795	84
X.1.17	SOP documents related to water-saving efforts	[16],[17]	0,955	9
X.1.18	Waste management documents in buildings	[16],[17]	0,793	85
X.1.19	Building wastewater management policy document	[16],[17]	0,894	16
X.1.20	IKE electricity according to reference standards	[18]	0,924	20
X.1.21	Energy consumption savings of 5% on average in 1 year	[18]	0,94	12
X.1.22	Building electrical IKE shows the reference standard IKE	[18]	0,942	11
X.1.23	IKE (Energy Consumption intensity) is more than 120%	[18]	0,922	21
X.1.24	Technical plan drawings of building envelopes	[16],[17]	0,889	17
X.1.25	RKS technical specifications of roof covering material	[16],[17]	0,907	14
X.1.26	Calculation of OTTV & RTTV values in standard worksheets	[16],[17]	0,909	13
X.1.27	Technical plan drawings of the building plan	[16],[17]	0,843	61
X.1.28	Manual WWR value calculation	[16],[17]	0,92	22
X.1.29	Calculation of the area of natural ventilation openings	[16],[17]	0,83	67
X.1.30	Calculation of the need for mechanical ventilation	[16],[17]	0,825	69
X.1.31	Calculation of air conditioning load (cooling load) in space	[16],[17]	0,828	68
X.1.32	Drawing of the location of the AC room & schematic diagram	[16],[17]	0,778	92
X.1.33	RKS Air Conditioning system	[16],[17]	0,89	37
X.1.34	RKS requirements kW/TR or COP value of AC equipment	[16],[17]	0,981	6
X.1.35	Technical plan drawings of floor plans and location	[16],[17]	0,837	64
X.1.36	RKS lamp specifications used	[16],[17]	0,912	26
X.1.37	Calculation of the level of artificial lighting	[16],[17]	0,986	4
X.1.38	Drawing of the technical plan of placement of light points	[16],[17]	0,841	62
X.1.39	Room area data along with the number of light switches.	[16],[17]	0,914	25
X.1.40	Technical plan drawings of lighting & wiring control	[16],[17]	0,832	66
X.1.41	RKS lighting sensor specifications used	[16],[17]	0,916	24
X.1.42	Technical plan drawing of natural lighting zone (SNI)	[16],[17]	0,839	63
X.1.43	Technical plan drawings of elevator floor plans	[16],[17]	0,823	70
X.1.44	Calculation of lift traffic analyses	[16],[17]	0,892	36
X.1.45	RKS elevator specifications & energy-saving features	[16],[17]	0,884	18
X.1.46	Technical drawings of escalator placement locations	[16],[17]	0,835	65
X.1.47	RKS escalator specifications and energy-saving features	[16],[17]	0,918	23

Table 2 continued

X.1.48	Calculation of electrical energy consumption plan	[16],[17]	0,881	19
X.1.49	Technical drawing of the electrical & kWh meter	[16],[17]	0,845	60
X.1.50	Technical drawing of BMS schematic & installation	[16],[17]	0,781	91
X.1.51	BMS input/output specification document and its parameters	[16],[17]	0,797	83
X.1.52	Technical drawing of electrical diagrams & renewable energy	[16],[17]	0,91	27
X.1.53	RKS specification of renewable energy sources	[16],[17]	0,991	3
X.1.54	Technical plan drawing of the installation of the water meter	[16],[17]	0,9	32
X.1.55	Have detailed technical drawings of the water meter	[16],[17]	0,905	29
X.1.56	Have a water meter specification document	[16],[17]	0,903	30
X.1.57	Water source document & the amount of water available	[16],[17]	0,894	35
X.1.58	Identification documents for the use of alternative water	[16],[17]	0,898	33
X.1.59	Has a calculation of existing water usage	[16],[17]	0,908	28
X.1.60	Have a water-saving plan calculation	[16],[17]	0,901	31
X.1.61	Have water balance calculations and water schematic drawings	[16],[17]	0,776	93
X.1.62	Documents on the type and specifications of sanitary ware	[16],[17]	0,8	82
X.1.63	Documents on the sanitary product to be replaced	[16],[17]	0,887	38
X.1.64	Documents on the number of water-saving sanitary	[16],[17]	0,885	39
X.1.65	Documents on the percentage of water-saving sanitary ware	[16],[17]	0,896	34
X.1.66	Waste management commitment (3R principle)	[16],[17]	0,85	58
X.1.67	Technical plan drawings of trash can facility details	[16],[17]	0,884	40
X.1.68	Drawing of the location of the polling station	[16],[17]	0,819	72
X.1.69	RKS requirements for placing trash cans in buildings	[16],[17]	0,874	46
X.1.70	Technical plan drawing of polling station collection	[16],[17]	0,818	73
X.1.71	Technical plan for organic & inorganic waste treatment	[16],[17]	0,821	71
X.1.72	Waste management operational technical flow chart image	[16],[17]	0,861	52
X.1.73	Waste management third-party engagement plan document	[16],[17]	0,848	59
X.1.74	Drawing of technical plan of waste handling equipment	[16],[17]	0,816	74
X.1.75	RKS provisions on how to handle and record waste	[16],[17]	0,863	51
X.1.76	Create a garbage generation logging format	[16],[17]	0,872	47
X.1.77	Has a smoking area located outside the Building	[16],[17]	0,812	76
X.1.78	Has detailed dimensions of no-smoking signs	[16],[17]	0,87	48
X.1.79	Analysis report of AC that uses refrigerant	[16],[17]	0,983	5
X.1.80	Documents on the checklist of AC equipment & refrigerant types	[16],[17]	0,783	90
X.1.81	Has technical drawings of room locations, & AC systems	[16],[17]	0,814	75
X.1.82	Has RKS air conditioning system and relative humidity	[16],[17]	0,878	43
X.1.83	Has room area data along with the number of light switches	[16],[17]	0,875	45
X.1.84	Has RKS sensor/lighting specifications	[16],[17]	0,877	44
X.1.85	Technical plan of the minimum natural lighting (SNI)	[16],[17]	0,809	77
X.1.86	Technical plan of the minimum lighting level (SNI)	[16],[17]	0,807	78
X.1.87	Plan operation and maintenance (O&M) of ME	[16],[17]	0,978	7
X.1.88	Waste management commitment letter (3R)	[16],[17]	0,944	10
X.1.89	Calculation of the amount of waste generation	[16],[17]	0,804	80
X.1.90	Technical plan waste container facilities (3 types of waste)	[16],[17]	0,805	79
X.1.91	RKS requirements for the placement of bins in buildings.	[16],[17]	0,867	49
X.1.92	Technical plan of the TPS location and the trash can	[16],[17]	0,802	81
X.1.93	Technical plan of organic waste and inorganic waste	[16],[17]	0,994	2

Table 3. Sub-Factors of the Construction Stage (X2)

	Sub-Factor	References	RII Index	Rank
X.2.1	Project work plan initiation document at the beginning.	[16],[17]	0,817	71
X.2.2	Project performance document for risk list priorities	[16],[17]	0,815	72
X.2.3	Data Building Information Modelling (BIM) Gedung	[16],[17]	0,966	8
X.2.4	The implementation of ideas and innovations in construction	[16],[17]	0,992	1
X.2.5	BGH operational efficiency planning design innovation.	[16],[17]	0,838	61
X.2.6	Making 5 types of public facilities (500 m of the site).	[18]	0,861	49
X.2.7	Create a public transport stop (300 m from the building gate)	[18]	0,8	79
X.2.8	Make bus stops supported with bus bay or lay by	[18]	0,798	80
X.2.9	There are walking facilities within the building area	[18]	0,856	51
X.2.10	Pedestrian facilities are available free from vehicular	[18]	0,796	81
X.2.11	Reducing the use of private motor vehicles	[18]	0,85	54
X.2.12	Create safe bicycle parking as much as 1 unit per 30 users	[18]	0,849	55
X.2.13	Dedicated bicycle shower for every 25 bicycle parking.	[18]	0,852	53
X.2.14	Make the soft-scape area at least 30% of the total land area.	[18]	0,795	82
X.2.15	Addition of 1 point for every 10% increase in tread area.	[18]	0,847	56
X.2.16	The use of 60% of local plants comes max 1000 km.	[18]	0,845	57
X.2.17	The use of productive plants, at least 10% of landscaping area.	[18]	0,854	52
X.2.18	Materials with an albedo value of at least 0.3 in the roof area	[18]	0,907	26
X.2.19	The use of green roofs is 50% of the roof area for ME	[18]	0,803	78
X.2.20	Materials with an albedo value of at least 0.3 non-roofing areas	[18]	0,905	27
X.2.21	Reduction of storm-water runoff by 50-75% (daily rain)	[18]	0,841	59
X.2.22	Implementing SPO control against pests, diseases & weeds	[18]	0,836	62
X.2.23	Provision of non-pet animal habitat of at least 5% site area	[18]	0,843	58
X.2.24	Sanitation repair of at least 5 units	[18]	0,84	60
X.2.25	Open pedestrian access without going through public areas.	[18]	0,814	73
X.2.26	Part of its open land is for public utilities (private green)	[18]	0,859	50
X.2.27	Revitalization of heritage buildings.	[18]	0,805	77
X.2.28	Monitoring and mobilization of construction equipment.	[16],[17]	0,927	16
X.2.29	Optimization of construction equipment tech utilization.	[16],[17]	0,982	4
X.2.30	Building safety documents against falling materials.	[16],[17]	0,936	12
X.2.31	Construction waste reduction calculation	[16],[17]	0,886	36
X.2.32	Construction waste calculation and sorting documents	[16],[17]	0,793	83
X.2.33	Special facilities for the location materials B3 waste	[16],[17]	0,909	25
X.2.34	Waste expenditure monitoring documents with third parties	[16],[17]	0,812	74
X.2.35	Construction waste 3R effort document within the project	[16],[17]	0,81	75
X.2.36	Recapitulation of the volume of products produced.	[16],[17]	0,884	37
X.2.37	Submit shop drawing work that testing & commissioning	[16],[17]	0,819	70
X.2.38	Submit list material approval, spec, & owner performance	[16],[17]	0,938	11
X.2.39	Test and commissioning documentation report	[16],[17]	0,791	84
X.2.40	Equipment system operation training documentation report	[16],[17]	0,925	17
X.2.41	Main equipment warranty certificate document	[16],[17]	0,916	21
X.2.42	Equipment system O&M manual document	[16],[17]	0,902	28
X.2.43	Submit a validated as-built drawing	[16],[17]	0,826	66
X.2.44	The visual image of the electrical substation	[16],[17]	0,82	69

Table 3 continued

X.2.45	Visual of sewage treatment plants, & fire protection plants	[16],[17]	0,863	48
X.2.46	Visual of religious, social, cultural, & service facilities	[16],[17]	0,79	85
X.2.47	Documentation of building materials to be demolished	[16],[17]	0,915	22
X.2.48	The organizational structure of demolition implementers	[16],[17]	0,833	63
X.2.49	Report on the Implementation of Demolition with RTB	[16],[17]	0,99	2
X.2.50	Documents of types of building materials (dismantled)	[16],[17]	0,913	23
X.2.51	Recyclable unloading material inventory documents	[16],[17]	0,9	29
X.2.52	Documents of demolition materials to be destroyed	[16],[17]	0,911	24
X.2.53	Demolition materials (damage the environment)	[16],[17]	0,987	3
X.2.54	The implementation of vegetation replanting	[16],[17]	0,866	46
X.2.55	Documentation of land that has been leveled	[16],[17]	0,788	86
X.2.56	Documentation of already planted plants	[16],[17]	0,864	47
X.2.57	Construction safety in the form (photo, plan, and installation)	[16],[17]	0,822	68
X.2.58	Documentation of used material (support dismantling)	[16],[17]	0,933	13
X.2.59	Inventory documents of reused dismantled materials	[16],[17]	0,918	20
X.2.60	Evaluation of the implementation of land restoration	[16],[17]	0,868	45
X.2.61	Compliance with demolition implementation report (RTB)	[16],[17]	0,807	76
X.2.62	Demolition & post-demolition implementation	[16],[17]	0,785	87
X.2.63	The collection of recycled materials post-dismantling	[16],[17]	0,979	5
X.2.64	Site plan where the material is collected, separated, and stored	[16],[17]	0,931	14
X.2.65	Follow-up recording of managed materials	[16],[17]	0,923	18
X.2.66	Recommissioning performance improvement MVAC	[18]	0,891	34
X.2.67	Continuous commissioning periodically (max of 3 years)	[18]	0,879	39
X.2.68	Improvement recommissioning (KW/TR) of MVAC Systems	[18]	0,889	35
X.2.69	Save energy consumption of room lighting (SNI)	[18]	0,951	9
X.2.70	Using high-frequency ballasts or LEDs in the workspace	[18]	0,875	41
X.2.71	The efficiency of equipment AC system in real-time	[18]	0,92	19
X.2.72	Provision of kWh meters AC, lighting & load contacts	[18]	0,893	33
X.2.73	Provision of kWh meters for unconditioned spaces	[18]	0,897	31
X.2.74	Routine recording of kWh meter data for at least 6 months	[18]	0,895	32
X.2.75	Displays a monthly energy consumption comparison	[18]	0,873	42
X.2.76	Equipment monitor technology support through EMS.	[18]	0,929	15
X.2.77	Conduct an external energy audit (level 2) once a year	[18]	0,871	43
X.2.78	A percentage of max power demand (renewable energy.	[18]	0,974	7
X.2.79	20% maximum power demand generated by renewable energy	[18]	0,898	30
X.2.80	CO_2 Emission Reduction Calculation	[18]	0,94	10
X.2.81	Construction waste calculation & assessment documents	[16],[17]	0,881	38
X.2.82	System planning design innovation document on BGH.	[16],[17]	0,977	6
X.2.83	Building quality innovation to increase efficiency	[17]	0,877	40
X.2.84	Approach innovation for increased efficiency	[17]	0,829	65
X.2.85	Agreement at criteria Existing Building	[17]	0,831	64
X.2.86	SPO & training the criteria of Green-ship Existing Building	[17]	0,87	44
X.2.87	Calculation of reducing construction waste	[16],[17]	0,824	67

Table 4. Sub-Factors of the Post-Construction Stage (X3)

	Sub-Factor	References	RII Index	Rank
X.3.1	Business Entity Certificate Document	[16],[17]	0,83	43
X.3.2	Certificate of Expert Building Management Manager	[16],[17]	0,998	1
X.3.3	Certificate of competence in expert customization activities.	[16],[17]	0,957	9
X.3.4	SOP Operation & Maintenance Organizational Structure	[16],[17]	0,913	12
X.3.5	As-built drawing	[16],[17]	0,988	4
X.3.6	Catalogue	[16],[17]	0,845	36
X.3.7	Equipment O&M manuals or manuals	[16],[17]	0,896	16
X.3.8	Data test com	[16],[17]	0,866	26
X.3.9	Building operation and maintenance manual	[16],[17]	0,996	2
X.3.10	Monthly report on the performance of BM	[16],[17]	0,911	13
X.3.11	Equipment operational parameters in the monthly logbook	[16],[17]	0,993	3
X.3.12	Periodic inspection report based on Preventive Maintenance	[16],[17]	0,985	5
X.3.13	Emergency response SOPs	[16],[17]	0,818	49
X.3.14	Business Entity Certificate Document	[16],[17]	0,827	45
X.3.15	The implementation of soft skills improvement training	[16],[17]	0,906	14
X.3.16	Photos & attendance list of soft skills training.	[16],[17]	0,82	48
X.3.17	The implementation of plant diseases and weeds	[16],[17]	0,842	38
X.3.18	Use of environmentally friendly materials.	[16],[17]	0,98	7
X.3.19	Environmentally friendly BGH socialization activities	[16],[17]	0,918	11
X.3.20	Proof Making building greenish information boards	[16],[17]	0,847	35
X.3.21	BGH occupant satisfaction survey above 70% (satisfied)	[16],[17]	0,901	15
X.3.22	AC system operation and maintenance guide	[18]	0,848	34
X.3.23	Guidelines for periodic maintenance.	[18]	0,816	50
X.3.24	Monthly Report on Operation and Maintenance Activities	[18]	0,891	17
X.3.25	As-built drawings, technical specs & documentation	[18]	0,837	40
X.3.26	Airflow documents following SNI	[18]	0,869	24
X.3.27	As-built drawings, technical specs, & photos of the AC system	[18]	0,835	41
X.3.28	AC equipment efficiency document (SNI)	[18]	0,84	39
X.3.29	As-built drawings, spec, and lighting system documentation	[18]	0,825	46
X.3.30	Room lighting level measurement (lux) to SNI	[18]	0,864	27
X.3.31	Monitoring and recording of actual energy consumption	[18]	0,862	28
X.3.32	Results of trend calculation in the form of graphs	[18]	0,867	25
X.3.33	Results of evaluation of energy consumption deviation	[18]	0,857	30
X.3.34	Elevator periodic maintenance reports	[18]	0,843	37
X.3.35	Actual energy measurement data for 6 months	[18]	0,873	22
X.3.36	Energy consumption does not 10% energy consumption	[18]	0,859	29
X.3.37	Report re-commissioning of the main equipment system	[18]	0,871	23
X.3.38	As-built drawings and technical specifications	[16],[17]	0,828	44

Table 4 continued

X.3.39	Water-saving sanitary equipment capacity test results	[16],[17]	0,85	33
X.3.40	A report measuring water consumption	[16],[17]	0,852	32
X.3.41	Results of calculation of actual water consumption data	[16],[17]	0,855	31
X.3.42	Technical drawings, equipment specs, & quality installations	[16],[17]	0,833	42
X.3.43	Measurement of temperature, humidity, airspeed, CO_2	[16],[17]	0,823	47
X.3.44	The integrated structure of building O&M	[18]	0,972	8
X.3.45	O&P organizational structure SOP document	[16],[17]	0,946	10
X.3.46	Design, Intent, and Owner's Project Requirement	[18]	0,882	19
X.3.47	Design, Intent, energy use, revitalization, and operations	[18]	0,886	18
X.3.48	Design, Intent, waiting for lift, revitalization, and operation	[18]	0,878	20
X.3.49	Design Project Requirements, certification, and operations	[18]	0,983	6
X.3.50	Design, Intent, landscape, revitalization, and operations	[18]	0,876	21

4. Discussion and Results

4.1. WBS Development

To equalize and rearrange the WBS structure, preparation is carried out based on the project work stage approach. Then to make the WBS arrangement according to the stage of work, the WBS grouping is arranged according to level or rank. Here's the level order for each level, as seen in Figure 3.

Level 1: Project (Green Retrofitting)
Level 2: Project Cycle
Level 3: Type of Work
Level 4: Process Methods and Support
Level 5: Activities

In preparing the WBS structure, is prepared based on the design and planning stage, construction stage, and post-construction stage, as follows:

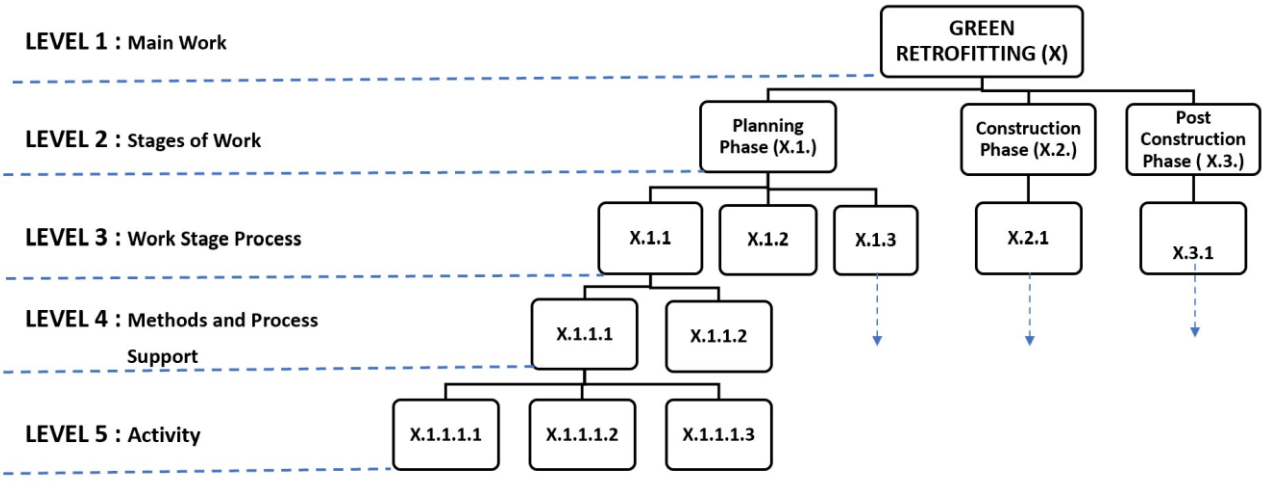

Figure 3. Structure of Green Retrofitting's WBS

Level 5, which is an activity, is a benchmark/parameter that needs to be achieved to obtain GBCI certification and PUPR Minister Regulation Number 21 of 2021. With the combination of GBCI benchmarks and the parameters of PUPR Ministerial Regulation Number 21 of 2021, it is expected to be a reference for green retrofitting work to obtain certification from GBCI and PUPR Ministerial Regulation Number 21 of 2021:

- ASD aspects: 19 types of work, 50 methods and process support, and 96 activities
- EEC aspects: 26 types of work, 77 methods and process support, and 162 activities
- WAC aspects: 19 types of work, 56 methods and process support, and 113 activities
- MRC aspects: 18 types of work, 50 methods and process support, and 127 activities
- IHC aspects: 23 types of work, 62 methods and process support, and 125 activities
- BEM aspects: 18 types of work, 51 methods and process support, and 105 activities.

4.2. RII Processing

A technique for examining the variables that have the greatest influence on the study object is the Relative Importance Index (RII). Additionally, this analysis method involved statistical computations using the questionnaire data as input, which were then processed into influencing factors. Based on the weighted value that the respondent provided after completing the questionnaire, RII derives the most important ranking variables [19].

To analyze the results of the respondent questionnaire, the method to be used namely RII. The results of the calculation of the RII value in level 5 activities of the WBS structure are divided based on the level 2 project cycle, namely the design and planning stage, the construction stage, and the post-construction stage.

Relative Important Index (RII) RII is a method of analyzing the most influential factors in the object of research. RII determines the most influential factor with a ranking system based on the weight of the scores given by respondents after filling out the questionnaire. The equation of the RII calculation is as follows [20].

$$RII = \sum W\ A \times N$$

Note:

RII: Relative Important Index

W: Weight (Weights range from 1 to 5)

A: Highest weight

N: Total Respondents

Independent variable (X): WBS Standard of 6 Aspects of Green Retrofitting in Retrofitting Work for High-rise Office Building Buildings based on GBCI and PUPR Minister Regulation Number 21 of 2021

Dependent variable (Y): Improved accuracy of resource planning.

Relative Importance Index (RII) to rank activities in the WBS structure has the most influence on the quality of resource planning. The results of calculating the RII value in WBS activities are as follows, which are divided into the design and planning stage, construction stage, and post-construction stage

Based on the RII value that has been done before, the RII value is ranked from the highest value that indicates the most influential activity. The ranking was carried out with RII analysis to see the green retrofitting work activities that most affected the quality of resource planning.

Only a few respondents were selected as sample data for the questionnaire survey. The determination of respondents aims to get optimal survey results because respondents are selected from professionals involved in a project. There are 6 target respondents in this study, which include Green Professionals, Project Managers, Site Managers, Contractors, Green Practitioners, and Cost Estimate Engineers.

This discussion describes the factors that influence the application of WBS development in the Green Retrofitting work of High-rise Office buildings. In determining the factors that affect the object of study, the author uses statistical analysis methods using simulation tools with the Relative Importance Index (RII). The results of the questionnaire are fed into this analysis method's statistical calculations, which are then converted into influencing factors. Based on the weight of the value provided by respondents after completing the questionnaire, the RII approach establishes the most influencing elements in the rating system. The Microsoft Excel 2019 application tool is used to run RII.

The initial stage of Relative Importance Index (RII) analysis is to collect questionnaire components that will be distributed to respondents. All components are arranged based on three parts, consisting of variables, main factors, and Subfactors, which can be seen in Tables 1, 2, and 3.

The results obtained from the questionnaire are the factors that most influence the application of WBS development in the Green Retrofitting work of High-rise Office buildings. This statistical analysis is compiled into a recapitulation which is presented in the form of a ranking of the most influential sub-factors.

Then the results obtained are as follows:

Table 5. Sub Factors Influential in the Planning Stage (X1)

Variable		Sub Factor	References	Index RII	Rank
X.1.	2.	Energy saving SOP document	[16],[17]	0,996	1
X.1.	93.	Technical plan drawing details of organic waste and inorganic waste processing facilities	[16],[17]	0,994	2
X.1.	53.	RKS specification of renewable energy sources and their use	[16],[17]	0,991	3
X.1.	37.	Calculation of the level of artificial lighting	[16],[17]	0,986	4
X.1.	79.	Show an analysis report of air conditioners that use refrigerant	[16],[17]	0,983	5

Table 6. Sub Factors Influential in the Construction Phase (X2)

Variable		Sub Factor	References	Index RII	Rank
X.2.	4.	Document on the implementation of ideas and innovations in construction methods	[16],[17]	0,992	1
X.2.	49.	Report on the Implementation of Demolition with the Technical Plan of Demolition (RTB)	[16],[17]	0,99	2
X.2.	53.	Inventory documents of demolition materials that damage the environment	[16],[17]	0,987	3
X.2.	29.	Optimization of construction equipment technology utilization.	[16],[17]	0,982	4
X.2.	63.	Documentation of the collection, separation, and storage sites of recycled materials post-	[16],[17]	0,979	5

Table 7. Sub Factors Influential in the Post-Construction Stage (X3)

Variable		Sub Factor	References	Index RII	Rank
X.3.	2.	Certificate of Expert Building Management Manager	[16],[17]	0,998	1
X.3.	9.	Building operation and maintenance manual	[16],[17]	0,996	2
X.3.	11.	Document the results of equipment operational parameters in the form of a monthly logbook	[16],[17]	0,993	3
X.3.	5.	As-built drawing	[16],[17]	0,988	4
X.3.	12.	Periodic inspection report based on Preventive Maintenance (PM)	[16],[17]	0,985	5

5. Conclusions

The green building concept also brings safety and health to its users so that their work productivity will increase [21]. Influential activities to improve the accuracy of resource planning are in the three stages of Green Retrofitting work based on GBCI and PUPR Minister Regulation Number 21 of 2021.

The preparation of the WBS structure of green retrofitting work can improve the quality of resource planning through detailed work, which is contained in level 5 of the WBS Structure from the implementation carried out which is guided by GBCI, and Regulation 21.

There is a relationship model that states the dominant.

The activity of the WBS structure of green retrofitting work from 6 aspects with the RII method, namely green retrofitting work activities which are divided into 3 (three) stages of work influence the quality of resource planning (Variable Y)

The ranking was conducted with RII analysis to see the green retrofitting work activities that are most important to the quality of resource planning.

The most dominant ranking is found in the Main factor of the design and planning stage.

While the most dominant Sub Factor:

(a) At the planning and design stage, namely: Management Policy Document 6 aspects of modification in existing
(b) High-rise office buildings
(c) At the construction stage, namely: efforts to utilize technology in optimizing the use of construction equipment
(d) In the post-construction stage, namely: certificate of competence of experts in modification activities.

Acknowledgements

The author would like to thank the University of Indonesia for the International Indexed Publication Grant (PUTI) Q2 Fiscal Year 2023-2024 Number: NKB-839/UN2. RST/HKP.05.00/2023

REFERENCES

[1] International Energy Agency, "World Energy Outlook 2022", November 2022, Website: www.iea.org

[2] Architecture 2030, "Actions for A Zero Carbon Built Environment - Existing Buildings", 2023. https://architecture2030.org/existing-building-actions/

[3] Yang, S., Cho, H. M., Yun, B. Y., Hong, T., & Kim, S., "Energy usage and cost analysis of passive thermal retrofits for low-rise residential buildings in Seoul", Renewable and Sustainable Energy, vol. 191, 2021 DOI: https://doi.org/10.1016/j.rser.2021.111617

[4] A. E. Husin, M. K. Ardiansyah, B. D. Kussumardianadewi, and I. Kurnaiwan, "A Study on the Application of Green Retrofitting in the Ready-Mix Concrete (RMC) Industry in Indonesia to Improve Cost Retrofitting Performance" Civil Engineering and Architecture, vol.11, no. 5A, 2023. DOI: 10.13189/cea.2023.110812

[5] F. Birol," Net Zero by 2050 - A Roadmap for the Global Energy Sector "IEA All rights reserved 2014 International Energy Agency Website: www.iea.org

[6] Anne Svendsen, P. C. Schultz, "Roadmap for An Energy Efficient, Low-Carbon Buildings And Construction Sector In Indonesia", Danish Energy Agency 2022. https://globalabc.org/sites/default/files/20228/Roadmap%20for%20an%20Energy%20Efficient%2C%20Lowarbon%20Buildings%20and%20Construction%20Sector%20in%20Indonesia.pdf

[7] Ibtihal, I., Latief, Y., Andhika, R., "Resource planning of mechanical and electrical work in apartment building based on WBS (Work Breakdown Structure)" Thesis, Department of Civil Engineering, University of Indonesia 2018, https://lib.ui.ac.id/detail?id=20473246&lokasi=lokal

[8] B.G. Hwang, L. Zhu, and J.T.T. Ming, "Factors Affecting Productivity in Green Building Construction Projects: The Case of Singapore", Journal of Management in Engineering, vol. 33, no. 3, 2016. DOI:10.1061/(ASCE)ME.1943-5479.0000499

[9] Project Management Institute, "A Guide to the Project Management Body of Knowledge", (PMBOK® Guide) – Fifth Edition 2013.

[10] W. Roswidiyastuti, "Kriteria Work Breakdown Structure Untuk Pengendalian Proyek yang Efektif", Thesis, Department of Civil Engineering, University of Indonesia 2009.https://lib.ui.ac.id/file?file=digital/2016-8/20248422-S50475-Windi%20Roswidiyastuti.pdf

[11] T. Hans, "Work Breakdown Structure: A Tool for Software Project Scope Verification", International Journal of Software Engineering & Applications, vol. 4, no. 4, pp. 19-25. DOI: 10.5121/ijsea.2013.4402

[12] Kumar, R., "RESEARCH METHODOLOGY" a step-by-step guide for beginners", SAGE Publications, 2014, Third edition

[13] Mufardis, B., Oktaviani, C. Z., & Buraida., "Proporsi Biaya Sumber Daya Manusia, Material dan Alat Pada Proyek Konstruksi Jalan", Journal of The Civil Engineering Student, vol. 3, no. 2, Agustus 2021, Halaman 127-133.

[14] Prayogo, D., Cheng, M.Y., Wong, F.T., Tjandra, D., Tran, D.H., "Optimization model for construction project resource leveling using a novel modified symbiotic organism search", Asian Journal of Civil Engineering, pp. 625–638, 2018. DOI: https://doi.org/10.1007/s42107-018-0048-x

[15] Kothari, C.R., "Research Methodology", New Age International (P) Limited, Publishers 1990, www.newagepublishers.com

[16] Minister of PUPR Regulation No. 21 of 2021, https://jdih.pu.go.id/detail-dokumen/2881/1#div_cari_detail

[17] Minister of PUPR Circular Letter No 01/SE/M/2022, "Bangunan Gedung Hijau - Petunjuk Teknis". https://jdih.pu.go.id/detail-dokumen/2927/1#div_cari_detail

[18] Green Building Council Indonesia, "Greenship Existing Building Version 1.1", June 2016.https://gbcindonesia.org/files/resource/093ec9dc-9f1d-47e3-805a-07887b8c4d81/Summary%20GREENSHIP%20Existing%20Building%20V1.1.pdf

[19] A.E. Husin, D. I. Rahmawati, M. Meisaroh, and B.D. Kussumardianadewi, "Performance Improvement of Box Girder Construction on Toll Road Projects based on M-PERT and VE", The Open Civil Engineering Journal, vol. no. 15, pp. 299-309, 2021. DOI: 10.2174/1874149502115010299

[20] A.E. Husin, and F. Sustiawan, "Analisa RII (Relative Important Index) Terhadap Faktor-Faktor yang Berpengaruh dalam Mengimplementasikan BIM 4D dan M-PERT pada Pekerjaan Struktur Bangunan Hunian Bertingkat Tinggi" Jurnal Aplikasi Teknik Sipil, vol.19, no. 4, 2021. DOI: http://dx.doi.org/10.12962/j2579-891X.v19i4.9336

[21] S. Sutikno, A.E. Husin, and M.M.E. Yuliati, "Using PLS-SEM to analyze the criteria for the optimum cost of green MICE projects in Indonesia based on value engineering and lifecycle cost analysis", Archives of Civil Engineering, vol. 68, no.4, pp. 555–570, 2022. DOI:10.24425/ace.2022.143054