Application of the Green Building Concept (BGH) in High-Rise Office Buildings Based on Hybrid Dynamics to Improve Cost Performance

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Abstract

Global warming, including droughts, rising sea levels, melting polar ice caps, and solar storms, poses a very serious and significant threat to the planet due to current climate change. Green Buildings (GB) are buildings that achieve significant and measurable results in saving energy, water, and other resources by applying BGH principles based on the function and classification of the project. The Indonesian government's latest regulation, through the Technical Guidance on BGH Performance Evaluation Standards of the Ministry of Public Works and Public Housing (PUPR) for 2022, is a way to reduce carbon emissions and achieve the net zero emissions (NZE) target by 2060. Regulatory Review: This study aims to analyze the factors that most influence the implementation of green buildings by the Minister of Public Works and Public Housing ministry of high-rise office buildings in indonesia towards increasing costs using the hybrid dynamic method, using Structural Equation Modeling (SEM) - Partial Least Square (PLS).

Keywords: *Green Building (GB), SEM-PLS, high-rise office buildings, Cost Performance, Hybrid Dynamic.*

A. INTRODUCTION

Climate change is a major threat to life and global development, one of the triggers of which is Green House Gas (GHG) emissions. In order to maintain the momentum of economic growth, Indonesia is carrying out a green economic transition that prioritizes inclusive and equitable low-carbon development. To smooth this transition, Indonesia has committed to reducing GHG emissions by 2030 by 29% under business as usual conditions and if collaborating with the international community, this can be increased to 41%.

In order to achieve this commitment, the Government has planned and begun implementing several strategic steps in several critical climate change sectors, namely the Forestry and Other sectors. Land Uses (FOLU), energy, agriculture, waste processing, and Industrial Process and Product Uses (IPPU). The biggest efforts made by the Government are in the forestry and land use sector or known as Forestry and Other Land Uses and the energy sector. These two sectors are the largest contributors to GHG emissions in Indonesia currently, with the FOLU sector producing around 60%, and the energy sector producing 36% (Press Release HM.4.6/432/SET.M.EKON.3/11/2021).

Figure 1. Indonesia's Environtment Index

Indonesia experienced a decline in all assessment groups. Based on the 2020 EPI, Indonesia's ecosystem vitality score is 43.7, then health is 29, and climate change is 54.4. In total, Indonesia's score was also better, namely 37.8. This score placed Indonesia in 116th place at that time, much better than its current position.

Indonesia still has several national priorities, and in line with these achievements, strives to continue to contribute to fighting climate change and achieving sustainable development goals. Rachmat Witoelar, Special Presidential Envoy for Climate Change Control stated, "The problem of climate change is not only an environmental problem, but is a development problem that we must address immediately. Disasters resulting from climate change can destroy decades of development gains in an instant, it is understandable that many parts of the Sustainable Development Goals are directly related to climate change" (www.kominfo.go.id, 2016).

Green property in Indonesia is not only in great demand, but has also become a necessity nowadays, especially in tall buildings. This was stated by the Chairman of the Indonesian Real Estate Certification and Advocacy Agency (REI) during the discussion 'Towards a Green Indonesia', Wednesday (27/6/2012). Property developers are encouraged to build buildings with a green building concept (Berita Satu, 2013). This is supported by the regulations created to regulate this, especially through the Minister of Public Development (PU) Regulation of 2014 which has been drafted and Jakarta Governor Regulation No. 38. which already existed. Indonesia itself has set a target to reduce greenhouse gas emissions by 26% by 2020. This is as stated in the Presidential Regulation of the Republic of Indonesia Number 61 of 2011 concerning the National Action Plan for Reducing Greenhouse Gas Emissions (RAN – GRK).

The author's research which leads to the concept of Green Buildings in Multi-Storey Offices based on hybrid dynamic to improve cost performance is very important to support reducing the impact of climate change. System dynamics models simulate real-world dynamic systems, providing the ability to simulate what could happen in the future and understand some key metrics.

B. LITERATURE REVIEW

1. Office

Environmental studies are integral to comprehending the potential ecological impacts associated with office projects. This encompasses an evaluation of natural resource utilization, potential effects on the surrounding ecosystem, and the formulation of mitigation strategies to uphold environmental sustainability. The financing planning stage involves an exploration of funding sources essential for project execution, encompassing financial feasibility analyses and the identification of relevant financing strategies (Kanuk et al., 2015; Astoeti & Dwijendra, 2022). Project feasibility studies encompass market, technical, economic, and financial analyses to ascertain the viability of successful project implementation.

The pre-design and design development stages play pivotal roles in articulating the project vision and plan. This involves the formulation of initial design concepts, identification of technical requirements, and the creation of a comprehensive project overview (Sumiyati & Purisari, 2018; Eddy et al., 2023). The terms of reference (TOR) are clarified to furnish precise guidelines for all involved parties. The technical issues check and final design stage entail a meticulous review of project technicalities, ensuring compliance with all requirements, and the preparation of a detailed engineering specifications document. The procurement of consultants through a tendering process is a crucial step to secure the requisite expertise and experience for the project (Wahyudi et al., 2023).

The appointment of a contractor involves selecting a winning bidder with the competence and capacity to execute the project. This process necessitates a thorough evaluation of the contractor's qualifications and experience. These step-by-step processes collectively establish a robust theoretical and practical foundation for the successful execution of office projects. They aim to minimize risks and ensure the project's environmental and financial sustainability.

Previous research on this matter delves into various aspects, as elaborated in the subsequent paragraph:

a. Identification of Permits: Previous studies may include an analysis of the permits required for similar projects in a particular area, this can include legal constraints, costs, and time associated with the licensing process (Astoeti & Dwijendra, 2022).
b. Environmental Studies: Previous research may address environmental impact evaluation methods, effective mitigation solutions, and the implementation of sustainable practices in construction and office projects (Eddy et al., 2023).
c. Financing Planning: Past literature may include analysis of various financing strategies that have been applied to previous infrastructure projects, along with

evaluations of successes and challenges that may have been encountered (Fadloli et al., 2023).

d. Project Feasibility Studies: Previous studies may include examples of project feasibility analyzes involving economic, technical, and social parameters. This can provide insight into the factors that are important in assessing the viability of an office project (Juliardi et al., 2018).
e. Pre-Design and Design Development Phase: Previous literature can provide examples of initial design concepts, challenges that may be encountered in this phase, and best practices for developing project designs effectively (Astoeti & Dwijendra, 2022).
f. Procurement of Bidding Consultants and Appointment of Contractors: Previous studies may include evaluation of the bidding process for consultants and contractors, with a focus on selection criteria, transparency, and implementation success (Hapsari & Putri, 2022).

2. Green Building Construction

Research on green buildings has emerged as a growing focal point, aligning with heightened global awareness of environmental and sustainability concerns. Several preceding studies substantiate the concept of green buildings, offering robust evidence regarding the consequential ecological, economic, and social advantages. A recurring theme in prior research underscores the pivotal role of energy efficiency in green building design. Investigations into the use of energy-saving technologies, environmentally friendly building materials, and the implementation of effective energy management systems consistently demonstrate significant reductions in energy consumption and carbon emissions (Juliardi et al., 2019).

Literature also indicates that green buildings yield economic benefits by curbing long-term operational costs. Practices such as efficient water management, the selection of sustainable materials, and the incorporation of architectural designs harnessing natural light contribute to enduring cost savings. Social benefits of green buildings, including enhanced occupant well-being and productivity, have been underscored in previous studies. The integration of interior designs that promote health, optimal thermal comfort, and the incorporation of green open spaces around buildings collectively fosters a superior environment for human inhabitants (Fadloli et al., 2023).

The literature sheds light on green building certification programs such as LEED (Leadership in Energy and Environmental Design) and BREEAM (Building Research Establishment Environmental Assessment Method), viewing them as tools for gauging and evaluating a building's sustainability performance. Previous research reveals that such certifications can incentivize best practices and offer economic inducements for building owners to invest in sustainable technologies and strategies.

This collective body of evidence underscores a robust consensus in favor of implementing green buildings as a sustainable solution. Such endeavors contribute to mitigating environmental impacts, providing economic advantages, and enhancing the quality of human life. These studies lay a crucial foundation for subsequent research and practical applications in the ongoing development of green buildings in the future (Hapsari & Putri, 2022).

3. System Dynamic

Research on dynamical systems has yielded a profound comprehension of the concept and its diverse applications, particularly in the modeling of dynamical systems. A multitude of prior studies has rigorously explored and refined the methodologies and principles that underlie dynamic system modeling. Descriptions of dynamic system models commonly incorporate variables, differential equations, and feedback mechanisms to depict the intricate relationships among interconnected elements within a system. These studies emphasize the critical role of parameter accuracy and data availability in constructing reliable models. Additionally, earlier research frequently delves into various simulation techniques and sensitivity analyses to assess the performance of dynamic system models under diverse scenarios (Abou & Alaboud, 2023).

Dynamic system models extend their reach across various fields such as economics, environmental science, supply chain management, health, and more. These studies endeavor to tailor the dynamic systems concept to accommodate the uniqueness and complexity of each subject. For instance, in an economic context, dynamic system models can be applied to predict economic growth, inflation, or changes in fiscal policy.

The articulation of the problem is a pivotal initial phase in crafting a dynamic system model. Existing literature underscores that a well-defined problem formulation enables researchers to identify key variables, parameters, and relationships crucial for inclusion in the model. These studies delve into the processes of model validation and verification, recognizing them as crucial steps in ensuring the reliability of simulation results. To construct effective dynamical system models, the literature reviews explore the utilization of software tools and techniques such as Vensim, Stella, or AnyLogic. Earlier research endeavors to compare the advantages and disadvantages of these various tools, offering practical guidance to assist in selecting the most appropriate tool for a given project (Juliardi, 2019).

This explanation provides a comprehensive and nuanced understanding of dynamic systems and their modeling. By delving into previous research, researchers can glean insights and a robust framework for designing, developing, and applying dynamic system models across various contexts and scientific disciplines.

4. Discrete Event Simulation (DES)

Research on Discrete Event Simulation (DES) constitutes a fertile area, with prior studies delving into the concepts, methodologies, and applications of discrete event simulation. These studies thoroughly explore diverse facets related to DES, offering valuable insights for its comprehension and application across various contexts. An exposition on DES typically commences with grasping the fundamental concepts, portraying a system as a sequence of discrete events occurring at specific points in time. Earlier research has delved into the mathematical principles underpinning DES, incorporating queuing, probability, and random variables to design models that faithfully represent the intricacies of the system (Sumiyati & Purisari, 2018).

DES models span a wide array of domains, including manufacturing, transportation, healthcare systems, and more. These studies vividly showcase the application of DES in modeling and analyzing the performance of complex systems. In the manufacturing sector, for instance, DES proves instrumental in designing and optimizing production flows, identifying bottlenecks, and assessing alternatives for production planning. The problem definition approach in DES frequently entails formulating mathematical models and selecting precise parameters to encapsulate system characteristics. Previous studies underscore the significance of model validation, encompassing verification and calibration techniques, to ensure simulations yield reliable results (Astoeti & Dwijendra, 2022).

The literature review underscores the paramount role of software tools in DES. Past research has undertaken comparisons among various DES platforms such as Simio, Arena, AnyLogic, and others, evaluating their capabilities and suitability for different simulation projects. The wealth of prior research on DES provides a comprehensive understanding of the concepts, applications, and methodologies associated with discrete event simulation. Through an exploration of these past studies, researchers can grasp the framework, challenges, and opportunities inherent in utilizing DES for modeling and analyzing complex systems, thereby fostering further knowledge development and applications in this field.

5. Cost

Research on cost variables, encompassing material costs, labor costs, equipment costs, corporate social responsibility (CSR) costs, fluctuations in production costs, and environmental costs, signifies a comprehensive understanding of the factors influencing the financial and operational sustainability of organizations. Material costs often constitute a significant component of a company's cost structure. Insights from previous research, such as the work of Juliardi et al. (2019), shed light on effective material cost management strategies in the manufacturing industry, emphasizing stock control and efficient supplier selection.

The role of labor costs in determining production costs and overall organizational productivity is crucial. A study by Eddy et al. (2023) provides an understanding of how human resource management practices influence labor costs and overall organizational performance. Equipment costs, encompassing initial investment, maintenance, and replacement, can significantly impact an organization's capital expenditures. Research by Astoeti & Dwijendra (2022) offers insights into managing equipment costs through the application of the Activity-Based Costing (ABC) method, enabling more accurate cost identification and allocation.

The costs associated with corporate social responsibility (CSR) have become prominent in finance and business literature. Work by Margolis and Walsh (2003) provides perspective on the impact of CSR costs on financial performance and corporate reputation. Fluctuations in production costs pose challenges to cost planning and control. A study by Wang et al. (2018) offers insights into leveraging information technology and risk analysis to navigate price fluctuations and enhance corporate resilience.

Environmental costs covering expenses related to sustainability and reducing environmental impacts, have garnered attention in sustainable finance literature. Research by Akram et al. (2022) illuminates how organizations can integrate environmental costs into their cost management systems. Prior research establishes theoretical and practical foundations for a deeper understanding of diverse cost variables. Organizations can enhance their cost management strategies by leveraging insights from this body of research, fostering greater efficiency and sustainability.

C. METHOD

The methodology employed to enhance cost performance in green office buildings comprises the following sequential steps: a) Gathering the variables utilized in the research; b) Conducting statistical tests through Structural Equation Modeling (SEM) - Partial Least Squares (PLS); and c) Investigating influencing factors derived from the results of SEM-PLS modeling in the discussion section of this research. Data analysis with SEM-PLS involves assessments of the outer loading test model, inner loading test, and good fit model test to discern the strength of the relationships between variables.

The research commenced with a thorough literature review aimed at gathering factors that influence the variables of Office Building (X1), Green Building (X2), Hybrid Dynamic (X3), and Cost Performance (Y). The indicators listed in the table correspond to the questionnaire employed in this study.

Tables 1, 2, 3, and 4 serve as the variables for analysis using SEM-PLS. These tables represent the primary focal points of the Green Building process stages in accordance with the Technical Instructions outlined in Minister of PUPR Regulation No. 1 of 2022 on office buildings. These stages are integral factors in the research, laying the foundation to elucidate the factors influencing the enhancement of Cost

Performance through the implementation of the Hybrid Dynamic method. With this contextual background, the identification of variables in the PUPR Minister's Green Building Regulation using the Hybrid Dynamic Method is established. These variables function as the X or independent variables, while the augmentation of Cost (Y) serves as the dependent variable.

Table 1. Office Variable (X1)

No	Sub-factors	Source	No	Sub-factors	Source
1	Licensing Identification	(Government Regulation No. 42, 2021) (Yakin, 2017)	14	Developing K4 Standards	(Government Regulation No. 42, 2021) (Simanjuntak et al, 2021)
2	Environmental Studies	(Government Regulation No. 42, 2021) (Yakin, 2017)	15	Work plan	(Government Regulation No. 42, 2021) (Manzoor et al., 2021)
3	Financing Planning	(Government Regulation No. 42, 2021) (Simanjuntak et al, 2020)	16	Field plan	(Government Regulation No. 42, 2021) (Chen et al., 2020))
4	Environmental Studies	(Government Regulation No. 42, 2021) (Yakin, 2017)	17	Procurement of materials	(Government Regulation No. 42, 2021) (Manzoor et al, 2021)
5	Term of Reference (TOR)	(Government Regulation No. 42, 2021) (Gaspersz et al,. 2019)	18	Mobilization of tools and energy	(Government Regulation No. 42, 2021) (Simanjuntak et al, 2020)
6	Project Feasibility Study	(Government Regulation No. 42, 2021), (Uif et alzcvx, n.d.)	19	Preparatory work	(Government Regulation No. 42, 2021)
7	Pre-Design Stage	(Government Regulation No. 42, 2021) (Effendi et al, 2021)	20	Shop drawing	(Government Regulation No. 42, 2021)
8	Design Development	(Government Regulation No. 42, 2021) (Alaydrus et al, 2018)	21	Construction Feasibility Test	(Government Regulation No. 42, 2021)
9	Check for technical issues	(Government Regulation No. 42, 2021) (Tama et al, 2020)	22	Operation and maintenance plan	(Government Regulation No. 42, 2021)
10	Final Design Stage	(Government Regulation No. 42, 2021) (Zainal et al, 2019)	23	Job Handover 1	(Government Regulation No. 42, 2021)
11	Procurement of Auction consultants	(Government Regulation No. 42, 2021) (Proboretno et al, 2022)	24	Job Retention	(Government Regulation No. 42, 2021)
12	Technical Specifications Document	(Government Regulation No. 42, 2021) (Zainal et al, 2019)	25	Handover of Work 2	(Government Regulation No. 42, 2021)

No	Sub-factors	Source	No	Sub-factors	Source
13	Contractor Appointment	(Government Regulation No. 42, 2021) (Haq et al, 2021)			

Source: Data Proceed

Table 1 above comprises a compilation of office variables essential for consideration in construction or development projects. Each of these variables encompasses sub-factors delineating specific elements pertinent to the project. These sub-factors were meticulously derived from diverse sources, including Government Regulation (PP) Number 42 of 2021 and research findings from various authors, such as Yakin, Simanjuntak, and others. The initial sub-factor, "Identification of Licensing," is anchored in PP No. 42 of 2021 and Yakin's research in 2017, forming the basis for comprehending the permit identification process within projects. This principle extends to other sub-factors, like "Project Feasibility Study," relying on PP No. 42 of 2021 and research conducted by Uif et al. This table furnishes a comprehensive overview of pertinent factors in office projects, serving as a readily accessible reference for further information. It proves invaluable for stakeholders, enhancing their capacity for more effective planning and execution of office projects.

Table 2. Green Building Building (X2)

No	Sub-factors	Source	No	Sub-factors	Source
1	Overall Thermal Transfer Value (OTTV) is a maximum of 35 Watt/m2.	(PUPR Technical Guidelines No. 1 Yr. 2022)	14	Recycled water from used water	(PUPR Technical Guidelines No. 1 Yr. 2022)
2	Electrical energy consumption < baseline	(PUPR Technical Guidelines No. 1 Yr. 2022)	15	Smoke-free building	(PUPR Technical Guidelines No. 1 Yr. 2022)
3	75% water saving fixture products	(PUPR Technical Guidelines No. 1 Yr. 2022)	16	Wood with non-B3 adhesive/coating	(PUPR Technical Guidelines No. 1 Yr. 2022)
4	Room with natural ventilation	(PUPR Technical Guidelines No. 1 Yr. 2022)	17	Building environmental waste disposal site	(PUPR Technical Guidelines No. 1 Yr. 2022)
5	Air conditioning with BMS	(PUPR Technical Guidelines No. 1 Yr. 2022)	18	Facilities with light sensors	(PUPR Technical Guidelines No. 1 Yr. 2022)
6	Ventilation system according to the latest SNI	(PUPR Technical Guidelines No. 1 Yr. 2022)	19	Clarity of entry and exit access	(PUPR Technical Guidelines No. 1 Yr. 2022)
7	CO2 concentration Max. 1000 ppm	(PUPR Technical Guidelines No. 1 Yr. 2022)	20	Implementation of water and energy efficiency	(PUPR Technical Guidelines No. 1 Yr. 2022)
8	CO max concentration. 25 ppm	(PUPR Technical Guidelines No. 1 Yr. 2022)	21	Traffic lift according to the latest SNI	(PUPR Technical Guidelines No. 1 Yr. 2022)
9	Concrete Material Complies with ISO 14000	(PUPR Technical Guidelines No. 1 Yr. 2022)	22	Equipment energy audit report	(PUPR Technical Guidelines No. 1 Yr. 2022)

No	Sub-factors	Source	No	Sub-factors	Source
10	Paint Material Complies with ISO 14001	(PUPR Technical Guidelines No. 1 Yr. 2022)	23	Proper use of materials	(PUPR Technical Guidelines No. 1 Yr. 2022)
11	Complete processing of waste	(PUPR Technical Guidelines No. 1 Yr. 2022)	24	Does not use Chloro Fluoro Carbon (CFC) material	(PUPR Technical Guidelines No. 1 Yr. 2022)
12	Lighting switch limit ≤30m2.	(PUPR Technical Guidelines No. 1 Yr. 2022)	25	Decent workers canteen	(PUPR Technical Guidelines No. 1 Yr. 2022)
13	KWh meter electricity usage	(PUPR Technical Guidelines No. 1 Yr. 2022)	26	Test the feasibility of Genset operation	(PUPR Technical Guidelines No. 1 Yr. 2022)

Source: Data Proceed

Table 2 presents a number of important criteria for constructing Green Buildings, which are known as environmentally friendly buildings. Each of these criteria is included by reference from PUPR Technical Guidelines No. 1 of 2022, which details the standards and requirements that must be met. For example, the first criterion is to ensure that the Overall Thermal Transfer Value (OTTV) value does not exceed 35 Watt/m2, which sets the energy efficiency standard.

The numbers in the table indicate the order of the criteria, while the sub-factors describe specific elements such as electrical energy use, building materials and waste management. All of these criteria are necessary to ensure that the building meets the requirements as a Green Building. By referring to PUPR Technical Guidelines No. 1 of 2022, stakeholders can ensure that building construction and management adhere to established sustainability standards.

Table 3. System Dynamic (X3)

No	Criteria (Sub Factors)	Source	No	Criteria (Sub Factors)	Source
1	Creating Dynamic System Models	O'Brien et al (2020)	5	Determining Problem Boundaries	Leon et al (2017)
2	Explanation of Dynamic System Models	Wuni Shen (2020), Remeser & Emsley (2016)	6	Green Ship Initial Costs	Rugeri et al (2020), Berone et al (2018)
3	Dynamic System Model Objects	Al Dakhel et al (2020), Wuni dan Shen (2020)	7	Operating Costs	Hu et al (2021), Sumani et al (2018)
4	Defining the Problem	Yildit et al (2019)			

Source: Data Proceed

Table 3 provides an overview of the criteria related to the System Dynamics approach, which is used to model and analyze complex systems. Each criterion or sub-factor in this table is accompanied by a literature reference source that can serve as a guide for readers to understand these concepts further.

First, the initial step in implementing System Dynamics is Creating a Dynamic System Model (No. 1), which is supported by the work of O'Brien et al in 2020. After that, the sub-factor Explanation of the Dynamic System Model (No. 2) refers to the interpretation model, with main references from Wuni Shen (2020) and Remeser & Emsley (2016).

Next is System Dynamics Model Objects (No. 3) highlighting what is modeled in System Dynamics, with literature support from Al Dakhel et al in 2020 and Wuni and Shen in 2020. Sub-factors Defining Problems (No. 4) emphasizes problem formulation, with the main reference from Yildit et al in 2019.

Determining Problem Boundaries (No. 5) involves limiting the scope of the problem, with supporting information from a study conducted by Leon et al in 2017. The table also includes extra aspects such as Green Ship Initial Costs (No. 6) and Operating Costs (No. 7), with main references from various relevant studies such as Rugeri et al (2020), Berone et al (2018), Hu et al (2021), and Sumani et al (2018).

Table 4. Discrete Event Simulation (X4)

No	Sub-factors	Source	No	Sub-factors	Source
1	Regular Events	(Kakiay, Simulation Systems Manager 2004)	3	Report Creation	(Kakiay, Simulation Systems Manager 2006)
2	Library Routine	(Kakiay, Simulation Systems Manager 2005)	4	Main Program	(Kakiay, Simulation Systems Manager 2007)

Source: Data proceed

Table 4 provides an overview of several sub-factors related to Discrete Event Simulation (DES), a simulation method that models and analyzes discrete events in a system. Each sub-factor is accompanied by a reference source that refers to the work of "Kakiay, Simulation Systems Regulator" from 2004 to 2007.

The Routine Event sub-factor (No. 1) refers to routine activities or events in the simulation, and the main reference source is the work "Kakiay, Simulation System Manager" in 2004. This shows that in the application of DES, routine event modeling is an important element that must be noticed. Then the Routine Library sub-factor (No. 2) relates to the routine library used in the simulation. The same reference source, namely "Kakiay, Simulation System Manager" of 2005, highlights the importance of having a solid library of routines in the DES simulation process.

The Report Generation sub-factor (No. 3) emphasizes the need to generate reports as a result of the DES simulation. The main reference still comes from the same work, namely "Kakiay, Simulation System Manager" in 2006. Main Program sub-factor (No. 4) refers to the main program used in DES, and the main reference source is "Kakiay, Simulation System Manager " in 2007. This shows that the selection and configuration of the main program is a key element in the implementation of DES simulations.

Table 5. Variable Costs (Y)

No	Sub-factors	Source	No	Sub-factors	Source
1	Material costs	(Suterisno & Munir, 2021) (Dipohsodo I,1996) (Kasimu, 2012)	4	Corporate social responsibility costs	(Dipohsodo I,1996) (Kasimu, 2012)
2	Labor costs	(Dipohsodo I,1996) (Kasimu, 2012)	5	Fluctuations in cost of production	(al. 1997)
3	Equipment costs	(Dipohsodo I,1996) (Kasimu, 2012)	6	Environmental costs	(Plebankiewicz, 2018)

Source: Data proceed

Table 5 provides an overview of several sub-factors related to the cost variable (Y), and each sub-factor is accompanied by a reference source that provides related guidance or understanding. Let's lay out this information in a narrative paragraph.

The Material Cost sub-factor (No. 1) relates to expenses related to materials in a project or operation. The main references include works by Suterisno & Munir in 2021, Dipohsodo I in 1996, and Kasimu in 2012. This shows that these three reference sources provide insight into the management and calculation of material costs. The Labor Costs sub-factor (No. 2) highlights expenses related to workers' wages and salaries. Key references also include works by Dipohsodo I in 1996 and Kasimu in 2012. Information from these sources can help in the understanding of labor cost management strategies, Table 5 provides an overview of several sub-factors related to the cost variable (Y), and each sub-factor is accompanied by a reference source that provides related guidance or understanding. Let's lay out this information in a narrative paragraph.

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The Equipment Cost sub-factor (No. 3) includes costs related to the procurement, maintenance and use of equipment in an activity. The reference sources are Dipohsodo I in 1996 and Kasimu in 2012. This shows that these sources can provide guidance on calculating and managing equipment costs. The Corporate Social Responsibility (CSR) Costs sub-factor (No. 4) is related to costs incurred in fulfilling corporate social responsibilities. The main references include works by Dipohsodo I in 1996 and Kasimu in 2012. This indicates that these reference sources provide information on how CSR costs can be managed and integrated into corporate financial policies.

Sub-factor Fluctuation in Cost of Production (No. 5) shows price instability in the production process. Although the reference source is not specifically stated, price fluctuations can be understood as a challenge in planning and managing production costs.

The preparation of the instruments in this research was obtained from the results of identifying sub factors as seen in Table 1 to Table 5, plus other sub factors, namely the Utilization and Dismantling Stages which influenced this research, totaling 206 variables, but due to limitations, the author did not display all the variables. the. Furthermore, the main research tool combining these sub factors consists of a questionnaire, which contains questions given to respondents based on various criteriaThe Equipment Cost sub-factor (No. 3) includes costs related to the procurement, maintenance and use of equipment in an activity. The reference sources are Dipohsodo I in 1996 and Kasimu in 2012. This shows that these sources can provide guidance on calculating and managing equipment costs. The Corporate Social Responsibility (CSR) Costs sub-factor (No. 4) is related to costs incurred in fulfilling corporate social responsibilities. The main references include works by Dipohsodo I in 1996 and Kasimu in 2012. This indicates that these reference sources provide information on how CSR costs can be managed and integrated into corporate financial policies.

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SEM-PLS Analysis

The result of this data processing is a model that shows the influence of the independent variable on the dependent variable and the order of the most significant variables. The minimum sample size was obtained based on the difference in path coefficient levels (p-Min) and a statistical power test of 80%. Table 6 is a reference table for determining the number of respondents based on previous research (Hair Jr et al., 2021). The author used this standard for testing the first model, so that the minimum sample size was based on a path coefficient value of 0.25 and a statistical power test of 80% at a significance level of 5% so that a minimum sample of 155 was obtained.

In SEM-PLS, it is assumed that the interaction between latent variables and indicator or manifest variables is measured on a homogeneous scale of zero and a variance of one (standard) as a result of which location parameters (constants) can be removed based on the example without affecting the generalization value. Non-parametric techniques are used to test the significance of parameters because SEM-PLS does not require a specific distribution to estimate parameters (Sutikno et al., 2023).

The first stage is Convergent Validity analysis which refers to the extent to which a measure is positively correlated with alternative measures of the same construct according to (Al-emran and Mezhuyev, 2019). The tools used to assess this are Composite Reliability and Cronbach's Alpha. A composite reliability value of 0.6-0.7 is considered to have good reliability (Sarstedt et al., 2022). Cronbach's alpha value was used to determine the internal consistency of the scale and the reliability value obtained for all variables and the entire scale used in the study was determined to be above 0.6. All indicators with an outer loading value > 0.5 based on the outer loading validity value state that all indicators have convergent validity as Average Variance Extracted (AVE).

Inner T-Value and Part Coefficients analysis is used. Where this analysis is a conceptual model that compares using the β value of each path; A larger β value has a greater influence on the endogenous variable, and the significance of the path coefficient is calculated via the T-test. To evaluate the significance of the hypothesis, the bootstrap process is used and the T-statistic value must be equal to or ≥ 1.96 at the 5% significance level according to (Sarstedt et al., 2022).

D. RESULT AND DISCUSSION

The number of respondents required is different from the requirements requested by the Smart SEM-PLS software, namely 302 respondents. This value was obtained from the initial SEM-PLS modeling. This resulted in additional distribution and collection time for questionnaires in this research.

Based on this, determining the number of respondents is more in line with the statement from Bagozzi & Yi in (Xiong et al., 2015), which suggests having a minimum sample size of 100 so that the results are quite reliable and suggests 200 to be more appropriate because less than that will increase risk of sample abnormalities and accuracy of results.

Outer Loading Test and Goodness-Fit Model

The modeling results show that all indicators with an outer loading value >0.5 are declared valid based on the outer loading validity value which states that all indicators have convergent validity as Average Variance Extracted (AVE) as shown in Table 6 below:

Table 6. Cronbach Alpha. Composite Reliability and Average Variance Extracted

	Cronbach's Alpha	rho_A	Composite Reliability	Average Variance Extracted (AVE)
Green Building Building (X2)	0.998	0.998	0.998	0.769
Implementation Stage (X2.2)	0.996	0.996	0.996	0.789
Utilization Stage (X2.3)	0.994	0.994	0.995	0.759
Planning Stage (X2.1)	0.993	0.993	0.993	0.817
Office (X1)	0.984	0.985	0.985	0.724
Hybrid Dynamic (X3)	0.973	0.974	0.977	0.792
Planning Stage	0.972	0.973	0.975	0.768
Disassembly Stage (X2.4)	0.971	0.972	0.976	0.817
System Dynamic (X3.1)	0.960	0.961	0.967	0.807
Implementation Stage (X1.2)	0.951	0.951	0.959	0.724
Operation and Maintenance Phase (X1.3)	0.943	0.945	0.959	0.854
Cost (Y)	0.940	0.948	0.951	0.711
Discrete Event Simulation (X3.2)	0.909	0.915	0.937	0.787
Internal (Y1.1)	0.906	0.918	0.928	0.685
Eksternsl (Y2)	0.811	0.812	0.914	0.841

Source: Data proceed

Based on the table above, it shows that the Composite Reliability (CR) value for each variable is above 0.70. The office variable has a CR value of 0.985, green buildings have a CR value of 0.998, hybrid systems have a CR value of 0.977, cost performance has a CR value of 0.951. With the values produced in the Composite Reliability test research, all variables have good reliability and are in accordance with the minimum value limits that have been determined.

The results of Cronbach alpha show that the Cronbach Alpha (CA) value for the office variable has a CA value of 0.984 > 0.70, the green building variable has a CA value of 0.998 > 0.70, the hybrid system variable has a CA value of 0.973 > 0.70 and the variable Cost performance has a CA value of 0.940 > 0.70 so these four variables have a high level of reliability. The Average Variance Extracted (AVE) value of cost, office, green building, system dynamic and discrete event simulation performance variables is > 0.50, which means that each variable has good discriminant validity.

Table 7. R – Square (R^2)

	R Square	R Square Adjusted
Implementation Stage (X2.2)	0.9942	0.9941
System Dynamic (X3.1)	0.9941	0.9941
Internal (Y1.1)	0.9924	0.9923
Planning Stage (X2.1)	0.9858	0.9857
Planning Stage	0.9824	0.9823
Discrete Event Simulation (X3.2)	0.9823	0.9823
Green Building Building (X2)	0.9803	0.9802

Utilization Stage (X2.3)	0.9778	0.9777
Cost (Y)	0.9702	0.9696
Hybrid Dynamic (X3)	0.9557	0.9554
External (Y2)	0.9553	0.9551
Operation and Maintenance Phase (X1.3)	0.9297	0.9293
Implementation Stage (X1.2)	0.9150	0.9144
Disassembly Stage (X2.4)	0.8856	0.8849

Source: Data proceed

The results of this research provide an in-depth understanding of the goodness-of-fit model through the R^2 value, which is taken from the results of data analysis at the outer loading stage of the model. The R^2 value plays an important role in measuring the extent to which the independent (exogenous) variable influences the dependent (endogenous) variable. The research results show that the significant R^2 value is 0.970, while the adjusted R^2 value reaches 0.871.

The R^2 value of 0.970 indicates that all independent variables together influence the Cost (Y) variable by 97%. In other words, about 97% of the variation in costs can be explained by the combination of the independent variables studied. Through the adjusted R^2 value which reaches 0.871, this research also confirms that the influence produced by all independent variables on the Cost variable (Y) is strong.

Emphasis on adjusted R^2 which exceeds the 50% threshold is a key indicator in assessing the strength of the influence of the independent variable on the Cost variable (Y). With an adjusted R^2 of 0.871, more than 50%, we can conclude that the joint influence of all independent variables on the Cost variable (Y) is significant and strong. These results provide confidence that the model used can well explain and predict changes in costs, and this can provide valuable guidance in financial management and planning in various organizational contexts.

Analysis of Inner T-Value and Part Coefficients

The bootstrapping method analysis has provided significant insight regarding the validity of the construct indices used in measuring the model structure. The results show that the modeled T-statistic value reaches or exceeds the critical threshold of 1.96, and the relationship between the factor load p-value and path coefficient shows a p-value smaller than 0.05. It can be concluded that all construct indices are considered valid for use in testing the structural measurement hypothesis, in accordance with the findings of Sarstedt et al. (2022).

Highlighting specific findings from the research results, variable X1.1.2 shows a P-Value of 0.000 for variable X1, indicating that the relationship between the two is significant. Likewise, variable X2.1.17 has a P-Values value of 0.000 against variable Variable X3.1.7 with a P-Values value of 0.000 on variable X3 confirms that the auditor quality variable has a significant influence.

Variable Y1.1 shows a P-Values value of 0.000, indicating that this variable has a significant influence on variable Y. This conclusion is strengthened by the significant value obtained through bootstrapping method analysis, providing a strong basis for confirming the relationship between variables in the model. Thus, the results of this research provide an important contribution in understanding and measuring the influence of various variables on the constructs tested, as well as offering valuable information for decision making at the organizational level.

E. CONCLUSION

Based on the results of questionnaire data testing, it shows that the most influential factors using SEM-PLS are offices, green buildings, dynamic hybrid systems on cost performance. Through the integration of features such as renewable energy systems, waste management and energy efficiency strategies, this building is able to optimize its operational costs in the long term. Return on Investment (ROI) analysis shows that the initial investment in the BGH concept can be justified through ongoing cost savings, creating a sustainable environment while optimizing operational efficiency. The use of environmentally friendly technology and management practices also has a positive impact on the environmental footprint, reducing carbon emissions and managing resources effectively. This is not only a financial achievement but also marks a positive contribution to corporate social responsibility and environmental sustainability.

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