Integration of Building Information Modeling (BIM) and Cost-Benefit Analysis (CBA) for Construction Claim Management

Zulfikar Ardi Satria[1] and Dyah Santhi Dewi[1,*]

[1] Department of Systems and Industrial Engineering, Faculty of Industrial Technology and Systems Engineering, Sepuluh Nopember, Surabaya, Indonesia
6010231064@student.its.ac.id
* dyah@ie.its.ac.id

Abstract. Construction claims pose persistent challenges in large-scale infrastructure projects, particularly within Indonesia's electricity sector. This study introduces an integrated approach that combines Building Information Modeling (BIM) and Cost-Benefit Analysis (CBA) to improve the claim management process at PT PLN (Persero). Traditionally, claim evaluations at PLN have relied heavily on technical considerations, often overlooking broader financial implications. This limited perspective has frequently resulted in project delays and suboptimal outcomes. By integrating BIM's strengths in visual modeling and project scheduling with CBA's capabilities in financial analysis, this research develops a comprehensive framework designed to support more transparent, data-driven decision-making in claim assessments. The proposed framework was applied to actual project data and validated through expert consultations with senior PLN professionals. Furthermore, a digital dashboard was developed to simulate various claim scenarios, enabling visualization of construction processes alongside their corresponding economic impacts. The results demonstrate that the BIM-CBA integration substantially improves the objectivity, efficiency, and accountability of claim evaluations. This approach empowers PLN to mitigate financial risks more effectively while maintaining compliance with project timelines and budget constraints.

Keywords: Construction Claims, Building Information Modeling, Cost-Benefit Analysis, Project Evaluation, Decision Support.

1 Introduction

1.1 Background

Electricity is a basic necessity that supports various aspects of life, including households, industries, transportation, and public services. As Indonesia's population and technology advance, electricity demand continues to grow. According to the International Energy Agency (IEA), global energy demand is expected to increase by 45% between 2008 and 2030. For Indonesia, the Ministry of Energy and Mineral Resources projects electricity demand will reach 1,885 TWh by 2060.

M. Rafieiy et al. (eds.), *Proceedings of the 8th Mechanical and Industrial Engineering Symposium (MIE 2025)*, Atlantis Highlights in Engineering 42,
https://doi.org/10.2991/978-94-6239-687-6_18

To meet this growing demand, substantial development of power infrastructure is required. Based on Indonesia's 2025–2034 Electricity Supply Business Plan (RUPTL), an additional 69.5 GW of generation capacity, 48,000 kms of transmission lines, and 108,000 MVA of substation capacity are needed. As the state-owned electricity company, PT PLN (Persero) is mandated to execute this expansion across the archipelago. One of its regional units, UIP Maluku Papua, is responsible for developing power plants, substations, and transmission lines in Eastern Indonesia.

However, infrastructure projects often face various challenges, including construction claims involving cost overruns, schedule delays, or compensation for disruptions. From 2019 to 2024, PLN UIP Maluku Papua recorded 90 contractor claims, most related to power plant and transmission line projects. Improper handling of such claims can lead to financial losses for both PLN and contractors. Delays or unjustified payments may exceed budget allocations, and mismanaged time extension claims can disrupt project schedules and increase costs. For example, in 2023, the cost difference between operating a diesel plant (PLTD) and a gas turbine plant (PLTG) was significant—Rp 8,748.35/kWh vs. Rp 1,238.95/kWh—resulting in a potential daily loss of over Rp 5.4 billion for a 30,000 kWh capacity project if delays occur.

Currently, PLN follows a framework for handling claims based on Technical Guidelines No. 0010.I/DIR/2024. This process starts with a claim proposal from contractors and involves evaluation by a Claims Evaluation Team. However, the existing framework lacks detailed methods and does not incorporate financial feasibility analysis.

To improve claim handling, the integration of Building Information Modeling (BIM) and Cost-Benefit Analysis (CBA) is proposed. BIM is a methodology widely used in the AECO industry for managing project models and identifying design inconsistencies. It enhances decision-making by providing 3D visualization, construction scheduling, and detailed material specifications. While BIM excels in technical representation, it lacks built-in economic analysis features. CBA complements BIM by providing structured financial evaluations to determine project feasibility and justify claims based on economic impact.

The combination of BIM and CBA can create a more comprehensive and transparent claim management process, potentially supported by a dashboard for real-time decision-making. This integrated method could become a reference for other organizations and support PLN's commitment to timely, cost-effective, and quality project delivery.

1.2 Objective and Scope

The primary objectives of this research are as follows:

1. To develop a construction claim management method through the integration of Building Information Modeling (BIM) and Cost-Benefit Analysis (CBA);

2. To implement and evaluate the effectiveness of the integrated BIM-CBA method in managing construction claims;
3. To analyze the applicability of the integrated approach and provide recommendations regarding its practical use, as well as to identify potential challenges in its implementation.

Scope and limitations in this study are the following:

1. The research is conducted within the context of PT PLN (Persero), specifically at the Maluku Papua Main Project Unit (UIP Maluku Papua);
2. The proposed method is applied to the development and execution of the Gas Engine Power Plant (PLTMG) project under PT PLN (Persero) UIP Maluku Papua;
3. The types of construction claims considered in this study are limited to variation orders (additional or reduced work) and extensions of time (EOT).

2. Literature Review

This chapter explores the theoretical foundations for managing construction claims through the integration of Building Information Modeling (BIM) and Cost-Benefit Analysis (CBA).

According to the Project Management Institute (2017), effective project management requires balancing stakeholder expectations within the constraints of scope, time, cost, and quality. Claims often arise during the execution phase due to discrepancies between contract clauses and field conditions (Dannyati, 2010).

BIM, first conceptualized by Eastman et al. (2011), enables digital visualization and coordination, substantially improving claim documentation, transparency, and conflict detection. Suermann (2009) highlights BIM's ability to reduce redundancy and enhance project efficiency. However, BIM alone lacks the capacity to assess the economic implications of claims. To address this gap, CBA—defined by Carteni et al. (2018) as a structured economic evaluation tool—can be integrated to quantify costs and benefits, validate claims, and inform resolution strategies.

Hassan et al. (2021) emphasize the significant potential of advanced digital technologies, particularly Natural Language Processing (NLP), in enhancing the management of contractual requirements and claims in construction projects. Their critical review highlights that the integration of NLP into contract management systems allows for the automatic extraction of critical information from contract documents. This capability reduces the likelihood of human error and facilitates faster identification of potential claims, thereby improving the overall efficiency and accuracy of claim management processes in the construction industry.

Biancardo et al. (2022) demonstrate that the integration of BIM and CBA enables simulation-based decision-making, improving accuracy and accountability in claim handling. However, despite these promising findings, there remains a significant gap in the literature concerning the practical application and validation of such integrated simulations in real-world construction projects, particularly in the context of large-scale, state-owned enterprises. Most existing studies have been limited to conceptual frameworks or hypothetical case studies without sufficient empirical evidence from operational environments. Furthermore, little attention has been given to the unique complexities of developing countries, where organizational, regulatory, and technological challenges may hinder the seamless adoption of BIM-CBA integration. This study seeks to address these gaps by proposing and testing a BIM-CBA simulation framework tailored specifically to the construction projects of PT PLN (Persero), Indonesia's state-owned electricity company. By focusing on a real-world application in a developing country context, this research aims to contribute not only to the theoretical advancement of integrated decision-support systems but also to provide actionable insights for practitioners dealing with construction claims under dynamic and resource-constrained conditions. The BIM-CBA integration concept proposed by Biancardo (2022) is illustrated in Fig. 1.

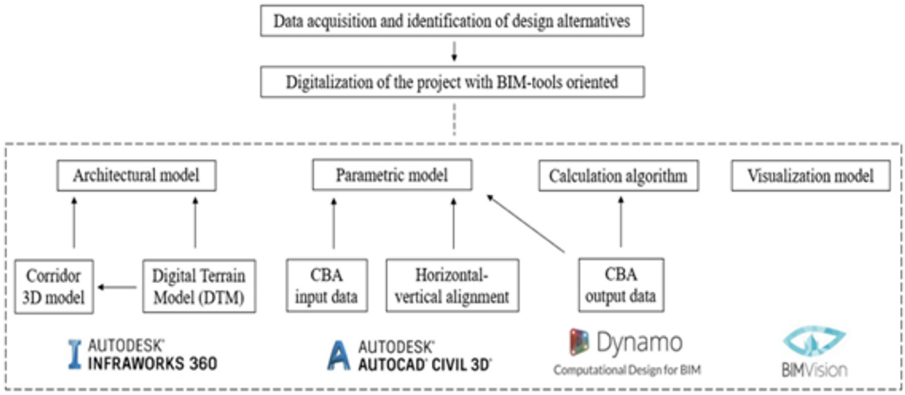

Fig. 1. BIM-CBA Integration Concept (Biancardo et al. 2022).

3. Methodology

This study employed a structured research methodology to develop an integrated approach using Building Information Modeling (BIM) and Cost-Benefit Analysis (CBA) for managing construction claims within PT PLN (Persero). The research began with a preliminary investigation of the existing claim handling process at PLN's Maluku and Papua Project Implementation Units, referencing internal technical guidelines. Observations and literature reviews were conducted to align theoretical frameworks with actual challenges in the field. The research methodology framework in this study can be seen in Fig 2.

The core issue identified was the absence of investment efficiency considerations and digital decision-making tools in PLN's current claim evaluation process. Therefore, the research aimed to (1) develop a claim management method integrating BIM and CBA, (2) implement and analyze the integrated method, and (3) assess its applicability and limitations.

A Focus Group Discussion (FGD) was conducted to support the method development. The FGD involved key stakeholders with relevant experience, following a structured protocol—from defining goals and selecting participants to discussion facilitation and reporting.

The BIM–CBA integration was simulated by selecting a case project, designing the BIM model, and conducting a CBA. BIM simulation followed four stages: conceptual planning, design development, construction documentation, and optimization. The CBA component evaluated costs and benefits, referencing performance indicators and investment metrics. Results were visualized using a custom-developed dashboard.

Expert validation and analysis were then carried out to ensure practical feasibility and relevance. Discussions included senior project and financial managers with over a decade of experience in project delivery and claim resolution at PLN.

The final recommendations were aimed at enhancing PLN's decision-making in construction claims through this integrated digital-economic framework. Conclusions were drawn based on research objectives, and suggestions were provided for future studies on broader implementation strategies.

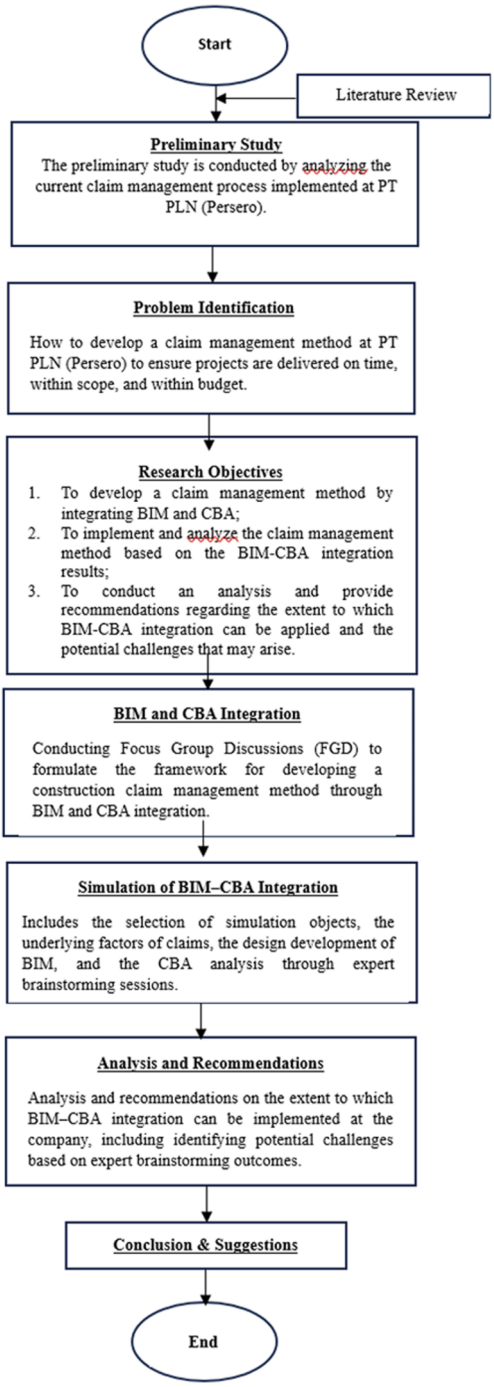

Fig. 2. Framework of Metodology

4. Result

4.1 Overview Claim Management

This chapter presents the core processes involved in construction claim management at PT PLN (Persero), focusing on the evaluation phase carried out by the internal claims assessment team. The primary objective at this stage is to identify and verify the volume of work submitted by contractors, including new items in variation orders (VO) and requests for extension of time (EOT). This verification ensures alignment with field conditions and project requirements, thereby avoiding inefficiencies. The evaluation process utilizes Microsoft Excel for volume calculations, based on 2D AutoCAD designs approved by the owner. However, these 2D models lack adequate visualization, which complicates the claim evaluation process, especially when determining the validity of the claimed components.

After volume approval, the next step involves a comprehensive assessment of the contractor's proposals, which includes evaluating changes in work methods and project timelines resulting from VO or EOT claims. Changes in execution methods have direct implications on labor, material, and equipment needs. Microsoft Project is employed to analyze resource requirements and ensure continued progress. The evaluation results serve as the basis for negotiations between PLN and the contractor. Once an agreement is reached, a negotiation report is prepared and forwarded to management for contract amendment approval.

4.2 Integration BIM-CBA

To enhance accuracy, objectivity, and efficiency in claim assessment, this study proposes an integrated approach combining BIM and CBA. A Focus Group Discussion (FGD) was conducted with stakeholders from the PLN Maluku and Papua Project Implementation Units to develop a framework for this integration. The FGD included senior managers, project control officers, and construction planning experts. Held virtually on June 2, 2025, the discussion sought to evaluate the feasibility and potential benefits of combining BIM's visualization capabilities with CBA's economic analysis.

The FGD revealed several key insights:

- Existing claim handling practices at PLN rely heavily on technical considerations, lacking economic feasibility assessments. Despite the recent adoption of BIM in design processes, its use in claim evaluation and project economics remains limited.
- Most participants acknowledged BIM's potential to enhance design accuracy and strengthen claim justification through detailed 3D visualization. However, they also noted that BIM, in isolation, does not adequately support strategic claim decisions.

- Participants responded positively to Biancardo's (2022) integration model, which emphasizes economic justification through CBA. They argued that using CBA alongside BIM allows the organization to assess the long-term financial and legal implications of claims more comprehensively.
- The proposed integration framework involves digitizing both existing conditions and post-claim scenarios using 3D BIM models, coupled with CBA evaluations that analyze costs, benefits, and technical risks.
- Four major challenges to integration were identified: disconnected systems between BIM and CBA, lack of interdisciplinary experts, insufficient owner commitment, and absence of standardized operational procedures.
- To mitigate the identified challenges, establishing a multidisciplinary team of experts from engineering, finance, and project management, supported by training and cross-disciplinary collaboration, can address the lack of expertise. Early involvement of project owners and a clear demonstration of the benefits of BIM-CBA integration—such as cost savings, risk reduction, and improved decision-making—are crucial to strengthen their commitment. Furthermore, developing standardized operational procedures with defined workflows, roles, and quality assurance protocols will ensure consistency and scalability across projects.

Key Recommendations from the FGD :

- Development of an interactive dashboard integrating geometry, time, and cost data.
- Claim scenario simulations using real project data and BIM-supported design.
- Cross-disciplinary collaboration among legal, BIM, and economic experts.

Proposed BIM-CBA Integration Process

Based on the FGD outcomes, the integrated model includes five major stages:

1. Claim Identification

In the claim identification stage, comprehensive contract documents—including technical specifications, construction drawings, Bill of Quantities (BoQ), and administrative records—are required to detect deviations between actual site conditions and contractual obligations. Building Information Modeling (BIM) functions as a digital platform to visualize project scope and progress, thereby supporting real-time monitoring of construction activities. This capability is crucial for identifying potential claim events such as design changes, project acceleration, and force majeure occurrences. The use of BIM at this phase significantly enhances the precision and efficiency of claim detection processes, enabling stakeholders to respond proactively.

2. Existing BIM Design

The existing BIM model is developed to reflect actual site conditions, aligned with the contractual documents and technical specifications. Presented in a three-dimensional (3D) format, it enables stakeholders to gain a holistic understanding of the project's physical state. Meanwhile, Cost-Benefit Analysis (CBA) plays a vital role in evaluating both financial and technical impacts. The CBA focuses on estimating incurred costs, identifying potential organizational benefits, and conducting a technical review of field changes. The integration of BIM and CBA at this stage provides decision-makers with comprehensive insights, ensuring a robust foundation for evaluating potential claims prior to formal submission.

3. Post-Claim BIM Design

Post-claim BIM models are created to incorporate adjustments proposed in submitted claims. These revised models, visualized in 3D, deliver a clear representation of project modifications and their implications. Concurrently, CBA assesses the financial and technical impacts of these changes, including additional costs borne by the organization, projected benefits, and technical ramifications of contract amendments. The BIM-CBA integration at this stage facilitates an equitable, transparent, and data-driven assessment of claims, supporting more informed resolution processes.

4. Model Visualization

Microsoft Power BI is utilized as an advanced visualization tool to present the integrated outputs of BIM and CBA. This platform displays dynamic infographics that combine visualized claim objects from BIM models, cost-benefit estimations, project progress indicators, and risk analyses derived from CBA. The interactive nature of Power BI dashboards enhances stakeholders' ability to interpret complex datasets efficiently. This approach not only promotes transparency but also supports data-driven decision-making, ensuring all stakeholders are equipped with accurate and timely information during claim evaluations.

5. Decision-Making Process

The decision-making stage constitutes the core of claim evaluation, relying on BIM-CBA integration as the primary reference framework. The 3D BIM visualizations provide stakeholders with detailed technical insights, while CBA offers a comprehensive financial assessment covering costs, benefits, and associated risks. This combined methodology enables decision-makers to identify the most appropriate solutions based on cost efficiency, time constraints, and potential impacts on project continuity. Ultimately, it supports decisions that align with contractual standards while fostering overall project success and sustainability.

The final model supports fair, transparent, and economically justified claim evaluations through visualization tools, cost-benefit metrics, risk assessments, and progress

tracking, enhancing PLN's claim management efficiency. Fig.3 illustrates the BIM-CBA integration model from the FGD results.

Comparison of Existing Conditions and New Method

The differences between the existing conditions and the results of the newly developed method in the context of claim management at PT PLN (Persero) UIP Maluku and Papua are presented in Table 1 below.

Table 1. Comparison of Existing Conditions and Proposed Method

Aspect	Existing Method	Proposed Method : BIM-CBA Integration
Database	2D documents (technical drawings)	3D digital model
Cost Claim Analysis	Limited to unit price comparisons and contract provisions	Comprehensive analysis based on CBA by comparing additional costs with benefits (financial and operational)
Time Extension	Based on narrative chronology and manual justification documents	Enhanced with project progress simulation and benefit values from decisions made
Transparency Process	Prone to debates and differences in object interpretation	More transparent and objective as it is based on digital data and quantitative analysis
Decision Making	Oriented towards the evaluator's experience	Data-driven, using BIM visualization and systematically calculated economic values
Stakeholder Involvement	Tends to be dominated by PLN's internal teams	Collaborative with other stakeholders
Aspect	**Existing Method**	**Proposed Method : BIM-CBA Integration**

Replication	Difficult to uniformly implement across all projects	Easily applicable to various projects using similar model templates and CBA analysis
Documentation	Scattered in physical forms and separate files	Centralized, digital, and traceable

4.3 Simulation of BIM-CBA Integration

This study explores the integration of Building Information Modeling (BIM) and Cost-Benefit Analysis (CBA) as a decision-support platform in managing construction claims, particularly in complex power plant projects within Indonesia's archipelagic regions. The research focuses on the PLTMG Tobelo project (10 MW and 20 MW) in North Halmahera, Maluku Utara, selected for its strategic importance under Indonesia's RUPTL 2025–2034 and its representation of logistical, geographical, and resource management challenges. The simulation involves defining the project scope, data collection during construction phases, and processing data through BIM for design visualization and CBA for evaluating financial impacts. Soil investigation revealed unexpected site conditions, prompting the contractor to propose additional works, including soil replacement and deep foundation construction, to address liquefaction risks. These changes necessitated comprehensive analyses of time and cost implications, with BIM providing detailed 3D visualizations and CBA offering quantitative evaluations for effective claim management.

The organizational framework supporting BIM implementation includes both contractor and owner teams, ensuring coordinated planning and execution across project phases. Using BIM, the study developed detailed plan layouts and 3D models of critical infrastructure such as the switchyard, integrating these with CBA outcomes in Microsoft Power BI to visualize cost-benefit dynamics pre- and post-claim. Expert validation through focused discussions provided practical insights into the integration's effectiveness, highlighting the approach's potential to optimize decision-making in similar projects. The findings underscore how BIM-CBA integration enables more transparent claim handling, improved risk mitigation, and enhanced communication among stakeholders, ultimately supporting PLN's efforts to deliver reliable and cost-efficient energy infrastructure in remote regions. The results of the BIM-CBA integration simulation in this study can be seen in Fig. 4.

4.4 Validation of BIM-CBA Integration

After the development of the claim management method at PT PLN (Persero) using BIM-CBA integration and the completion of its simulation, the next stage was the

analysis of the research results through a question-and-answer session with experts, with the detailed findings presented in Table 2.

Table 2. Analysis of Expert Verification Results

Aspect	Verification Results
Number and Profile of Experts	1.) Three employees from PT PLN (Persero), consisting of two individuals holding the position of Sub-Division Manager and one individual holding the position of Unit Project Implementation Manager; 2.) Possess a minimum of 10 years of professional experience.
Verification Method	Interviews and discussions
Verification Results	1.) The integration process of BIM and CBA in handling construction claims is assessed as a highly relevant methodological innovation to meet PLN's strategic needs, particularly in the context of digital transformation and efficient investment management. This integration model provides a new framework that not only focuses on the technical aspects of projects but also emphasizes long-term economic considerations aligned with the principle of value for money; 2.) The integration of BIM and CBA is considered capable of supporting increased objectivity in claim evaluations. The 3D visualization through BIM greatly assists in monitoring physical progress and identifying deviations, while CBA plays a crucial role in measuring cost impacts and benefits in detail;

Aspect	Verification Results
	3.) From the perspective of fieldwork implementation, the BIM-CBA integration is deemed effective in accelerating decision-making processes in projects; 4.) The BIM-CBA integration offers a financial breakthrough for PLN by enabling claim assessments that account for both nominal values and long-term risks.
Improvement Recommendations	1.) Development of standardized operational procedures for BIM-CBA integration in specific projects; 2.) Preparation of training programs for relevant human resources, particularly across functions (engineering, engineering economics, legal); 3.) Implementation of a pilot project to test the effectiveness of the BIM-CBA dashboard before nationwide adoption.

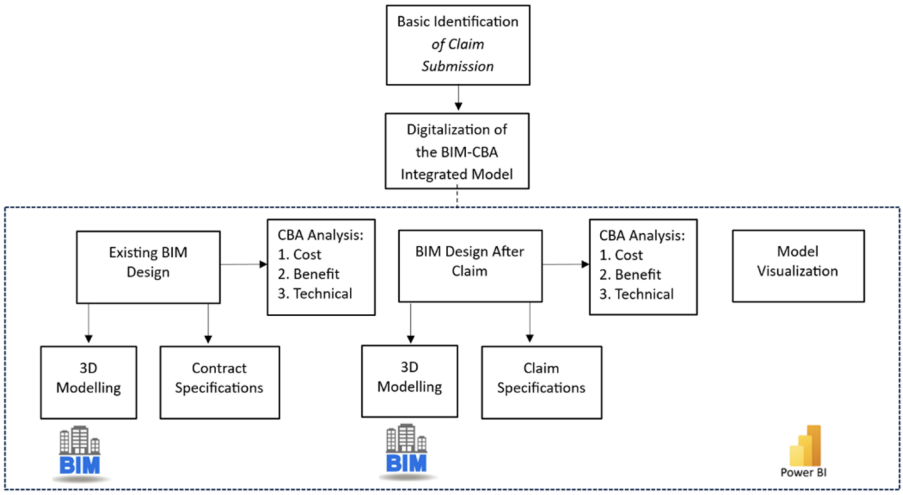

Fig. 3. Conceptual Model BIM-CBA

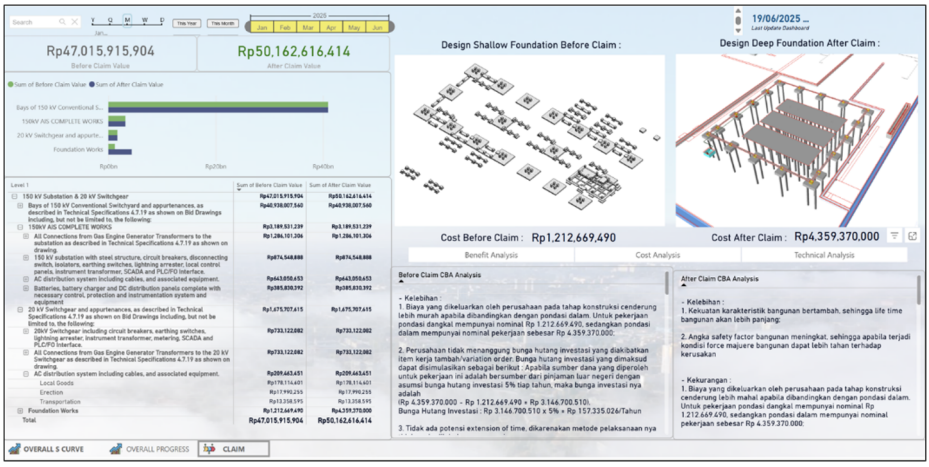

Fig. 4. BIM-CBA Integration Simulation

5. Conclusion

This study presents an integrated approach to construction claim management by combining Building Information Modeling (BIM) and Cost-Benefit Analysis (CBA), with specific application in PT PLN (Persero)'s infrastructure projects, particularly at the Maluku Papua Project Unit. The motivation stems from the increasing volume of

construction claims and inefficiencies in PLN's existing claim evaluation processes, which are heavily reliant on 2D modeling and lack comprehensive economic assessments.

Through literature analysis, stakeholder discussions, and simulation on a real-life gas engine power plant project, the research identified critical limitations in the current system—namely the absence of investment efficiency analysis, limited visualization capabilities, and fragmented decision-making tools. The Focus Group Discussion (FGD) revealed strong support for integrating BIM's 3D modeling and scheduling strengths with CBA's financial assessment capability to enhance objectivity and strategic value in claim evaluation.

The proposed BIM-CBA integration model consists of five key stages : Claim Identification, Existing BIM Design, Post-Claim BIM Design, Model Visualization, and Decision-Making Process. This framework emphasizes the use of a real-time dashboard (e.g., Microsoft Power BI) to enable transparent, data-driven decisions across technical, economic, and legal dimensions.

The integration of BIM and CBA not only improves the accuracy and fairness of claim assessments but also enhances stakeholder understanding and supports timely resolution. By simulating alternative scenarios and quantifying both technical and financial impacts, the model offers a holistic and replicable solution for PLN and potentially other infrastructure organizations facing similar claim management challenges.

In conclusion, the study recommends the adoption of this integrated method as a strategic step toward digital transformation in construction claim handling. It also highlights the need for cross-disciplinary collaboration, system integration, and standardized procedures to ensure successful implementation.

6. Suggestion

1. Future research is recommended to develop a standardized framework along with implementation guidelines for BIM-CBA integration across various types of construction projects. Moreover, subsequent studies may focus on mitigating potential barriers, such as limited understanding of BIM-CBA, the need for training programs for BIM-CBA managers, and the formulation of internal policies to support the method's adoption.

2. The development of an interactive BIM-CBA-based dashboard should be continued and expanded into a centralized digital platform connected to project databases and decision-making modules. This advancement is expected to enhance the efficiency of claim evaluation processes and strengthen transparency in project management.

3. To further test the model's validity, future studies are encouraged to apply the BIM-CBA integration model to other types of projects. This would provide a more comprehensive understanding of the suitability of various scenarios in claim management through the utilization of BIM-CBA integration.

References

1. Biancardo, S. A., Gesualdi, M., Savastano, D., Intignano, M., Henke, I., & Pagliara, F. (2022). An innovative framework for integrating cost-benefit analysis (CBA) within Building Information Modeling (BIM). Applied Sciences, 12(22), 11754. https://doi.org/10.3390/app122211754
2. Cartenì, A., Henke, I., & Molitierno, C. (2018). A cost-benefit analysis of the metro line one in Naples, Italy. WSEAS Transactions on Business and Economics, 15, 529–538.
3. Dannyati, E. (2010). Optimalisasi Pelaksanaan Proyek dengan Metode CPM (Studi Kasus Twin Tower Building Pascasarjana Undip) [Undergraduate thesis, Universitas Diponegoro].
4. Eastman, C., Teicholz, P., Liston, K., & Fischer, M. (2011). BIM Handbook: A Guide to Building Information Modeling for Owners, Managers, Designers, Engineers and Contractors (2nd ed.). Wiley.
5. Government of Indonesia. (2012). Government Regulation Number 14 of 2012 concerning Electricity Supply Business Activities.
6. Hassan, F. U., Le, T., & Le, X. (2021). Addressing legal and contractual matters in construction using natural language processing: A critical review. Journal of Construction Engineering and Management, 147(9), 03121004. https://doi.org/10.1061/(ASCE)CO.1943-7862.0002122
7. Kukulanga, R., et al. (2011). Construction contractors claim process framework. Journal of Construction Engineering and Management, 137(4), 309–314. https://doi.org/10.1061/(ASCE)CO.1943-7862.0000294
8. PMI. (2017). A Guide to the Project Management Body of Knowledge (PMBOK Guide) (6th ed.). Project Management Institute.
9. PT PLN (Persero). (2024). Technical Guidelines for Contract Amendments of Unit and Central Contracts in the Directorate of Project Management and New and Renewable Energy, Regulation Number 0010.I/DIR/2024.
10. PT PLN (Persero). (2024). Electricity Supply Business Plan (RUPTL) of PT PLN (Persero) 2025–2034. Jakarta: PT PLN (Persero).
11. Shaqour, M. (2022). The role of implementing BIM applications in enhancing project management knowledge areas in Egypt. Ain Shams Engineering Journal, 13, 101778. https://doi.org/10.1016/j.asej.2021.09.030