

CHAPTER I

INTRODUCTION

1.1. Background

The construction industry is one of the strategic sectors that contributes greatly to global economic growth. Along with the rapid development of digital technology, various industry sectors have transformed in the way they manage data, coordinate, and make decisions. However, compared to other sectors such as manufacturing, the rate of digitalization in the construction industry is still relatively low because it is difficult to adapt to new technologies [1], [2]. This condition causes problems in project management and internal coordination, so the contracting company is encouraged to adopt an information system to improve the operational effectiveness of project management.

PT. Bolo Dewo Utomo (PT BDU) is a company engaged in providing generator set installations. Generator Set (generator) is a set of combined equipment of two devices, namely *Engine* as a driving engine and generator or alternator as a power plant [3]. The installation of generator sets (generators) itself is an important part of construction activities, especially in the scope of work *Mechanical, Electrical, and Plumbing* (MEP), which supports building infrastructure and industrial facilities [4]. The generator set installation process also includes the construction of the foundation, installation of vibration dampers, installation of cables, ventilation systems, *exhaust, grounding*, as well as the merger with the building's main power distribution system. Thus, it can be concluded that generator set installation activities are included in construction projects that require structured project management.

Currently, PT BDU as a generator installation provider does not have a special system to manage projects in a structured manner. Business processes from the pre-project stage to handover are still done manually, project data is spread across various important documents. An interview with PT BDU, revealed that there were difficulties in tracking important documents such as Work Orders (SPK), *Design Genset Approval*, and the Handover Minutes. Project progress report from the field by *Project manager* is still carried out through communication applications such as *Posted by E*, which causes difficulties when tracking archives. Inefficient progress reporting processes lead to delays in information, thus hindering management in monitoring project status *real-time* [5]. Osorio-Gomez et al. (2024) said that the lack of

information centralization is the main cause of administrative inefficiency in construction companies [6]. Based on other research by Wijaya and Mulyati (2022), it is also emphasized that uncentralized data and manual data management have an impact on the occurrence of errors in the ordering and calculation process, thereby slowing down performance in a project [7]. This weakness directly impacts the company's competitiveness, because the effectiveness of the time, cost, and quality management system is a Key Competitive Indicator (KCI) assessed by clients in choosing a contractor [8].

Project delays occur when the execution of work does not go according to the planned schedule. This has the potential to increase project costs, lower the quality of work, and affect the contractor's reputation in future projects [9]. The problem of delays is one of the critical issues in the construction industry that is often the main trigger for financial losses [10]. The importance of time management is underscored by the research of Shen et al., who found that *construction time* (construction time) is the most important indicator for contractors on projects related to buildings and facilities [8]. McKinsey (2020) reported that the average construction project experienced delays of up to 20% of the original plan and cost overruns of up to 80% [11].

Based on PT BDU's internal documents in the form of project delay warning letters in the 2024 period, as many as seven projects were recorded as late in completion from the contract schedule. The letters show that delays are generally caused by delays in *progress* reports, field coordination, and untimely payments. This condition shows that PT. BDU does not yet have a system that is able to monitor project progress in *real-time* and provide early warning of potential delays.

To overcome these problems, a system is needed that not only records data, but is also able to provide early warnings (Early warning) against the risk of delay. A based approach Machine Learning as used by Egwim et al. (2021) requires large amounts of historical data [10], while the Earned Value Management (EVM) must have complete initial planning data in the form of cost plans and schedules documented in detail from the beginning of the project [12]. Both approaches are not suitable for medium-sized companies such as PT BDU which do not have *Database* large and structured projects, as well as inconsistent planning documentation.

In this study, the Fuzzy Tsukamoto method was chosen as the algorithm for the delay detection module for several reasons that correspond to the characteristics of

this study. Fuzzy logic is designed to handle linguistic uncertainty, a common condition in construction project assessment where the boundary between "late" and "not late" is not absolute. Among the fuzzy methods that exist, Tsukamoto was chosen because of its monotonous consequences as conveyed by Sri Kusumadewi & Purnomo (2010) [13]. This monotonous nature allows the value of the membership function limit to be determined directly through expert interviews without the need for statistical historical data. In addition, each rule IF-THEN on Tsukamoto instantly generates a value Crisp without additional defuzzification processes so that it is more efficiently implemented in an information system based on *Web* by *real-time*. The development of this web-based information system uses the Waterfall method because the needs of PT BDU's system have been clearly defined from the beginning through interviews. The sequential Waterfall method ensures that each stage is completed in a structured manner before moving on to the next stage, so that the quality of the system is better maintained and the potential for errors is minimized [14].

Although various studies have been conducted regarding the detection of construction project delays, research linking logic *fuzzy* into a project management information system based *Web* is still limited, especially for the domain of generator installation projects. Rachmawati et al. (2023) have proven that the fuzzy approach is effective for late risk assessment in generator-based power generation projects, but the developed model is still based on MATLAB which has not been integrated in the information system and has not used operational variables that are easy to monitor *real-time* [15]. This research seeks to fill this gap by developing a project management information system equipped with a delay detection module using Fuzzy Tsukamoto based on the variables of the percentage of payment realization and the percentage of running time duration, which produces an output in the form of a delay risk index in the form of a percentage as a support for PT BDU's management decision-making.

1.2. Problem Formulation

1. How to design and develop a web-based generator installation project management information system that can integrate project activities at PT BDU?
2. How to design a delay detection module with Fuzzy Tsukamoto to detect potential project delays?
3. What are the results of the system testing using the Black Box Testing method, System Usability Scale (SUS), and accuracy testing on the Fuzzy Tsukamoto algorithm to ensure that the system is suitable for use at PT BDU?

1.3. Research Objectives

This study aims to create a generator installation project management information system with delay detection using *the tsukamoto fuzzy* algorithm.

1.4. Research Benefits

The benefits of this research are:

1. Providing a web-based project management information system solution that can assist PT Bolo Dewo Utomo in managing generator installation projects to be more efficient, measurable, and transparent.
2. Provides a delay detection module with the Fuzzy Tsukamoto algorithm that is able to detect potential project delays early on and provide automatic alerts to management.
3. It is a reference for further research in the field of project management information system development, especially in the application of Fuzzy Tsukamoto.
4. Encourage the implementation of digital transformation in generator installation companies and strengthen the competitiveness of the generator installation industry through the use of integrated information systems

1.5. Research Limitations

This research is limited by the following scope:

1. The object of research is limited to PT. Bolo Dewo Utomo and only focuses on generator installation projects that have been or are running.

2. The project data used is limited to the period of 2020–2025, according to the availability of documents and company access.
3. The developed system is focused on basic project management modules (including project data management, work progress, documents, and payment data) as well as the main feature in the form of detection of potential delays using the Fuzzy Tsukamoto method. This system does not accommodate functionality modules beyond the limitations of *the pre-designed* Use Case.
4. Detection of delays using the Fuzzy Tsukamoto method based on *expert judgement* at PT. Bolo Dewo Utomo. The variables used in the delay assessment process with the Fuzzy Tsukamoto method are limited to two main indicators, namely:
 - a. Project payment status
 - b. Project time
5. System testing was carried out using the Black Box Testing method, usability evaluation using the System Usability Scale (SUS), and algorithm accuracy testing.
6. System implementations are limited to web-based environments and are not developed in the form of mobile applications or external system integrations.