CHAPTER I
INTRODUCTION

This chapter contains explanations related to the background, objectives, scopes of the problem and systematic writing of the report that has been carried out at the Teluk Bayur Port.

1.1 Background of Research

Indonesia, as the largest archipelago in the world, has more than 17,000 islands that stretch along strategic international trade routes. With a geographical position at the crossroads of the Indian and Pacific Oceans, and flanked by the world's busiest shipping lanes such as the Malacca Strait, Sunda Strait, and Lombok Strait, Indonesian ports play a crucial role in supporting the flow of domestic and international goods. This geographical potential provides a strategic advantage for Indonesia to become a center of maritime logistics and trade.

According to the Ministry of Transportation (2018), as much as 90% of the world's trade routes are transported by sea, and 40% of the trade passes through Indonesia. This shows that the role of trade by sea has great potential to support the economy in Indonesia. According to a report by the Central Statistics Agency (BPS), the sea transportation sector contributed around 6.94% to the national Gross Domestic Product (GDP) in 2019 (Setiajadi, 2020). This contribution value continues to increase along with the growth of international trade. In addition, data from the Coordinating Ministry for Maritime Affairs and Investment shows that major ports in Indonesia handle more than 17 million TEUs (Twenty-foot Equivalent Units) per year. This data reflects the large role of sea logistics in supporting export and import activities in Indonesia (Chauhan, 2023). This activity must, of course, be supported by adequate port infrastructure and operational policies that support activities at the port.

Ports are water areas that are protected against waves, which are equipped with marine terminal facilities, including docks where ships can moor for loading and unloading goods, marine warehouses (transito), and storage places where ships unload their cargo, and warehouses where goods can be stored for a longer time while waiting for delivery to the destination or shipment (Triatmodjo, 2009). According to Law No. 21 of 1992 concerning Shipping, a port is a place consisting of land and surrounding waters with certain boundaries as a place of government activities and economic activities that are used as a place for ships to dock, up and down passengers and loading and unloading goods equipped with shipping safety facilities and port support activities as well as a place for intra and intermodal transportation.

Ports in Indonesia are managed by a state-owned enterprise, PT PEL. The company has four operating regions with a total of 95 ports, which are responsible for providing and operating port services. PT PEL Region II has operated in 10 provinces and manages 12 ports in Indonesia. One of the ports managed by this company is Teluk Bayur. Teluk Bayur Port has a role as one of the economic gateways in the western region of Indonesia and one of the busiest ports, as well as the largest port on the west coast of Sumatra Island. Teluk Bayur Port is the most important commercial port that can help the economic development of West Sumatra Province and its surroundings. (Hadiguna & Nisa, 2013).

Based on the interview results, it was found that currently Teluk Bayur Port is equipped with modern equipment capable of handling various types of goods. Teluk Bayur Port is able to serve a wide range of dry bulk, liquid bulk, and general cargo commodities. Teluk Bayur Port has services in the form of port ponds, pilot & tug services, port infrastructure facilities including docks, dolphins, and moorings, warehouses, yards, goods handling and equipment, container handling operations, bulk cargo handling operations, and port land area utilities & property for more productive businesses. Activities at Teluk Bayur Port have several divisions to manage their activities, such as divisions that carry out transportation

and storage activities are the Scouting Division, Rendalops, Container Terminal, and Terminal Business Division.

Teluk Bayur Container Terminal has existing facilities in the form of a 1,565-meter-long jetty, 18,401 square meters of storage warehouse, and a large stacking yard. Facilities for loading and unloading include 4 units of forklifts, 4 units of head trucks, 4 units of excavators, 1 unit of wheel loaders, 1 unit of side loaders, and 7 units of cranes. Crane is a tool for unloading or loading containers from ships to the dock or stacking field and vice versa. This tool is the first tool to operate after the ship has moored. By using this tool, there are many advantages that can be achieved, one of which is the speed of loading/unloading goods so that it can save time. Teluk Bayur Port has seven units of cranes with a carrying capacity of 30 ton SWL as a goods transfer system at the port that functions as a loading and unloading tool, allowing the transfer of various types of cargo, including containers and bulk, from ships to docks or to land. The loading and unloading data of the Port in 2024 can be seen in **Tabel 1.1**.

Table 1.1 Loading and Unloading Data of the Port in 2024

Month	Tonnage
January	84.435
February	99.664
March	43.444
April	91.371
May	122.877
June	47.735
July	102.984
August	110.273
September	124.711
Oktober	70.099
November	75.684
December	92.014
Total	**1.065.291**

All loading and unloading from the ship to the dock is done by the crane. Data collection of loading and unloading goods at the company is carried out once

a month. In the monthly container loading and unloading data at Teluk Bayur Port, it can be seen that the total loading and unloading demand from January to December reached 1,065,291 tonnages. The company prioritizes high service levels to offer to customers so that productivity becomes the company's main goal. Although high productivity is the main goal, this company also pays attention to the utility of its resources due to fluctuating demand. The large quantity of goods transported by cranes as shown in **Table 1.1** shows that the overall operation of cranes is very important in the process of loading and unloading goods at the company. Optimal crane performance ensures smooth distribution of goods, reduces vessel dwell time, and improves port operational efficiency. Disruptions or inefficiencies in the crane system can have a direct impact on productivity, operational costs, as well as customer satisfaction, making good crane maintenance and management a crucial aspect in supporting smooth logistics activities at the port. Optimal crane performance depends not only on its design and capacity, but also on the reliability of its driving force. Drive systems, whether electric or fuel oil-based, play an important role in ensuring efficient, stable and sustainable crane operations. Proper selection and maintenance of the power source will support the smooth loading and unloading process, reduce downtime, and improve overall port productivity.

Cranes in Teluk Bayur Port previously used diesel as fuel. Not only these cranes, until now there are still many cranes used at PT PEL Region II branch ports using on-board diesel genset as the main power source with fuel type, namely High Speed Diesel (HSD). The cost of fuel, lubricants, maintenance, repairs, labor and so on required to operate cranes is quite large. Exhaust emissions and splashes of fuel and lubricants can reduce environmental quality in the port and its surroundings. The following is presented in **Table 1.2** data related to the amount of operational costs incurred by the company in 2023 for the use of cranes with diesel. The total cost includes fuel, lubricants, maintenance, repairs, and labor.

Table 1.2 Total Crane Operational Cost with Diesel

Crane Unit	Cost Each Crane (Rp)
1	Rp837.847.570,00
2	Rp929.824.200,00
3	Rp710.305.459,00
4	Rp633.531.300,00
5	Rp672.839.972,00
6	Rp745.739.915,00
7	Rp813.719.719,00
Total Cost	**Rp5.343.808.135,00**

However, since June 2024, these cranes have switched their main fuel to electricity. Teluk Bayur Port uses electricity from the PLN substation which is placed in the crane operation area. This is not the first time an electrification program has been carried out at this port company. The electrification program has been completed at 2 (two) ports, namely Panjang Branch port and Priok Branch port, while Pontianak Branch and Palembang Branch ports are under construction. It is the right decision if this port company intends to carry out an electrification program that aims to replace the function of on-board diesel generators with PLN power as the main power source for cranes, with the aim of reducing operating costs and exhaust emissions so as to help achieve "green port" status gradually. At the initial stage, detailed planning was carried out for the construction of the power house, network and electrical components of loading and unloading equipment to obtain investment costs.

This electrification program is currently in the trial phase. During this period, a performance evaluation of the electrification program is carried out by observing its operational performance with particular focus on the operational costs incurred. By considering these operational conditions, it can be estimated whether electrification at Teluk Bayur port is feasible to be realized so that the port service company as the owner can obtain financial benefits in terms of reduced operational costs.

This research also adds environmental analysis before and after electrification. When making the energy transition from fossil fuels to electricity, it is not enough just to consider the operational cost, but other aspects need to be considered, one of which is the evaluation of effects on the environment. This environmental analysis considers the carbon emission footprint released by cranes when using these two power sources. This analysis is expected to show which power source leaves the least carbon footprint. When companies measure and report carbon emissions, they can better understand the main sources of emissions and their environmental impacts. Sudibyo (2018) adds that this process creates pressure, both from inside and outside the organization, which encourages increased transparency and accountability to stakeholders such as investors, customers and regulators. Reduced exhaust emissions, reduced fuel spillage, and improved air quality around the port should be reported regularly. If the results show that electrification has a considerable positive impact, this program will be further supported as a real step towards a green port.

Switching to electric energy sources opens up opportunities for significant emission reductions, but at the same time presents a variety of potential risks ranging from supply reliability, peak load costs, to the impact of implementation on the smooth operation and readiness of human resources and maintenance of new equipment. These potentials were then identified and mapped by the company as a basis for determining the most appropriate steps before electrification was fully implemented. The company has set several alternative solutions from the start as an anticipatory step against potential risks that may arise during the electrification process, such as the reliability of electricity supply, peak cost burden, and the readiness of human resources and maintenance systems. Although the company has already implemented some of these alternatives, a decision analysis is conducted to validate and evaluate the degree to which these decisions conform to established technical and strategic criteria, as well as to provide an objective weighting of other alternatives that may be relevant in the future.

To determine the most appropriate alternative, a set of assessment criteria is used, which is compiled based on references from Justin (2021) regarding relevant criteria in making maintenance action decisions. However, not all criteria from the reference are used directly. Some criteria are adjusted to the actual conditions in the field to be more contextual to the operational characteristics of the port and the energy efficiency goals that the company wants to achieve.

After the implementation of the electrification program for cranes at Teluk Bayur Port, the next stage that became the main focus of management was monitoring the performance and evaluating the results of the program. This evaluation is conducted to ensure that the main objectives of electrification, namely operating cost efficiency and the realization of a green port can be achieved as planned. Monitoring of environmental aspects also needs to be kept in mind. According to Husgafvel & Sakaguchi (2023), optimal environmental impact management ensures that company growth remains aligned with the principles of sustainability and social responsibility, and contributes to global efforts to address climate change. Rachmawati (2021), also states that disclosure of carbon emissions has a close relationship with improving the company's environmental performance.

1.2 Problem Formulation

The problem formulations contained in this research are as follows.

1 Is the electrification of cranes at Teluk Bayur Port feasible to continue by considering operational costs before and after implementation?

2 Is the electrification of cranes at Teluk Bayur Port feasible to continue by considering carbon emission before and after implementation?

3 What alternative actions can be prioritized to support the efficient and reliable use of electricity in crane operations?

1.3 Objectives of Research

The objectives that contained of this research are as follows.

1. To evaluate the system of loading unloading crane using electricity and fuel by considering the amount of operational costs
2. To evaluate the system of loading unloading crane using electricity and fuel by considering the amount of carbon emission.
3. Identify prioritized alternative actions to support efficient electricity use.

1.4 Scopes of Research

Based on this research, there are scopes to the problems that exist during the process are as follows.

1. The goods transfer system at the port is assumed to only be operational using diesel oil and electricity sources.
2. Standard operating procedures for loading and unloading services remained the same and did not change during the study.

1.5 Outline of Writing

The systematics of writing this report are as follows.

CHAPTER I INTRODUCTION

Introduction that explains the background of research, problem formulation, research objectives, scopes of the research and outline of this report.

CHAPTER II LITERATURE REVIEW

The theoretical basis chapter describes the theories related to research on the Container Terminal system, Container Terminal transportation equipment and transportation equipment fuel usage. These theories are

obtained from various sources such as journals, books, theses and final assignments related to this research.

CHAPTER III RESEARCH METHODOLOGY

The research methodology chapter explains the stages and steps in conducting research starting from initial observations to the research site to getting conclusions from the results of this study.

CHAPTER IV DATA COLLECTING AND PROCESSING

The data collecting and processing chapter contains data collected and data processing of operational cost and carbon emission

CHAPTER V RESULT AND ANALYSIS

The result and analysis chapter contains the analysis after doing the calculation of research that have been carried out previously

CHAPTER IV CONCLUSION

The conclusion chapter contains the conclusions drawn from the data processing and analysis conducted in this research, along with suggestions based on the findings and recommendations for future studies.

CHAPTER II
LITERATURE REVIEW

The theoretical basis chapter describes the theories related to research on the Container Terminal system, Container Terminal transportation equipment and transportation equipment fuel usage. These theories are obtained from various sources such as journals, books, theses and final assignments related to this research.

2.1 Port

According to Law No. 17/2008 on Shipping, a port is defined as a place consisting of land and/or waters with certain boundaries as a place of government activities and business activities used as a place for ships to dock, embark and disembark passengers, and/or load and unload goods, in the form of terminals and ship berths equipped with shipping safety and security facilities and port support activities, as well as a place for intra-and intermodal transportation movements. According to Triatmodjo (2009), a port is a place consisting of land and waters with certain boundaries, used for government and economic activities, such as berthing, anchoring, loading and unloading passengers, and/or loading and unloading goods, equipped with shipping safety facilities and port support, as well as a place for intra- and intermodal transportation.

The port is a gateway to enter a region or country and as a connecting infrastructure between regions, between islands or even between countries, continents and nations. With this function, port development must be accountable both socially, economically and technically (Triatmodjo, 2009). The port has an area of influence (hinterland), which is an area that has an interest in economic, social and other relations with the port. For example, West Java and even Indonesia are the areas of influence of the Port of Tanjung Priok, or the Port of Makassar has an area of influence in the form of islands and surrounding seas. Imported goods,