Handling Analysis of Liquefied Petroleum Gas in Reducing Waste: A Case Study in Indonesia

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Abstract. This research aims to identify the factors influencing waiting times in the operations and reduce the waste that occurs in LPG Integrated Terminal Teluk Kabung operations. This study utilizes secondary data to report the following values: a DPMO value of 36,960 and a sigma value of 3.29 in April, a DPMO value of 46,246 and a sigma value of 3.18 in May, a DPMO value of 45,610 and a sigma value of 3.19 in June, and a DPMO value of 44,908 and a sigma value of 3.20 in July. A significant contributor to waste is prolonged waiting times for truck deliveries, exacerbating delays in tank space availability. Subsequent enhancements include GPS installation, partnerships with SPBE collaborators, and proactive maintenance of truck engines to streamline distribution processes. Forecasting methodologies are employed to optimize waiting for ullage, aiming to mitigate operational delays and enhance efficiency across the terminal.

Keywords: Waste, Waiting, DPMO, Sigma Level.

1 Introduction

Indonesia is an archipelagic country with more than 16,000 islands and a land area of around 2.012 million km². This country has a long coastline, reaching 99,093 km², and a sea area of 5.8 million km², including an exclusive economic zone of 2.7 million km². By mid-2022, Indonesia's population will reach around 275.77 million, with the growth trend continuing [1]. Research conducted by Yurlis Sartika and Syamsul Amar has shown that increasing population significantly impacts the demand for energy sources, such as LPG. LPG consumption in Indonesia has continued to increase since 2011, supported by demand data, which continues to increase yearly [2].

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Fig. 1. LPG Consumption Chart.

LPG (Liquefied Petroleum Gas) is an energy source used in various sectors of society, including households, industry, and transportation [3]. LPG is a mixture of propane and butane stored in carbon steel cylindrical tanks at a pressure of 760 to 1030 Kpa [4]. LPG use has increased by 30% to support the industrial sector, with specific prices set for several industrial sectors through Presidential Regulation 121 of 2020. PT Pertamina Patra Niaga, a commercial trading subholding company of Pertamina (Persero), manages various energy products, including fuel, lubricants, LPG, asphalt, and petrochemical products [5]. One of the terminals PT Pertamina Patra Niaga manages is the Teluk Kabung Integrated Terminal, located in Padang City, West Sumatra, Jambi and Riau. This terminal receives, stores and distributes LPG from supply sources in Cilegon, Banten. However, LPG operations at this terminal often experience wasted time in the loading and unloading process, which causes unproductive waiting time. This is a challenge faced by LPG operations at the Teluk Kabung Terminal.

2 Methodology

2.1 Waste

Waste can be defined as an activity that does not provide added value from the input process to the output during the process from being made until the goods are distributed to customers [6]. According to Suhartono, in the journal [7] TPS (Toyota Production System), several types of waste appear in a company's business processes: defects, overproduction, waiting, non-utilized talent, transportation, inventory, motion, and excess processing.

2.2 Lean Six Sigma

Lean is an approach that involves various tools and techniques to reduce waste in business processes. The main goal of Lean is to increase added value to products or services by focusing on consumers [8], [9]. It is done sustainably by identifying, reducing, and eliminating various types of waste. The Lean approach maximizes efficiency in all business processes by identifying and optimizing all activities [10]. Several values usually appear in a business process: value-adding activity, non value adding activity, and necessary non-value-adding activity [11].

2.3 Fish Bone Diagram

Fishbone diagrams, also known as cause and effect diagrams, are used to identify the main factors influencing quality and their consequences for the problem. This diagram not only identifies the main factors but also presents more detailed factors that contribute to those main factors, illustrated with fishbone-like arrows [6], [12]. The main principle used in the Fishbone diagram is brainstorming. Implementation of this diagram helps in finding the root of problems that arise. When the cause of the problem has been found, corrective steps can be taken more quickly because the root has been identified. Moreover, this diagram helps show all the possible causes of the problem clearly and in detail [13].

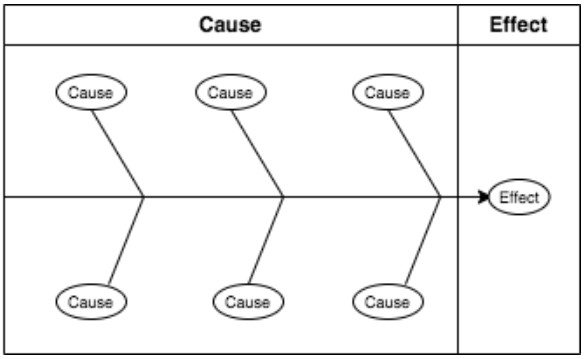

Fig. 2. Example of a Fishbone Diagram.

2.4 Brainstorm

Brainstorming is a technique designed to encourage groups to freely contribute various ideas without prior critical assessment [12], [13]. Each group member contributes with their noted ideas, combined with other ideas. The ultimate goal is to agree on the next steps in problem-solving or concept development. Brainstorming is a form of developing a discussion method where group members participate by providing their ideas, suggestions, opinions, information, and thoughts regarding a problem [14].

In another context, brainstorming is also defined as a method that allows groups of people to generate many ideas [15] quickly. This method teaches individuals to search, find, and convey as many ideas as possible to improve the process. Brainstorming aims to facilitate better communication and collaboration between group members and reach an agreement on the next steps in solving problems or developing concepts.

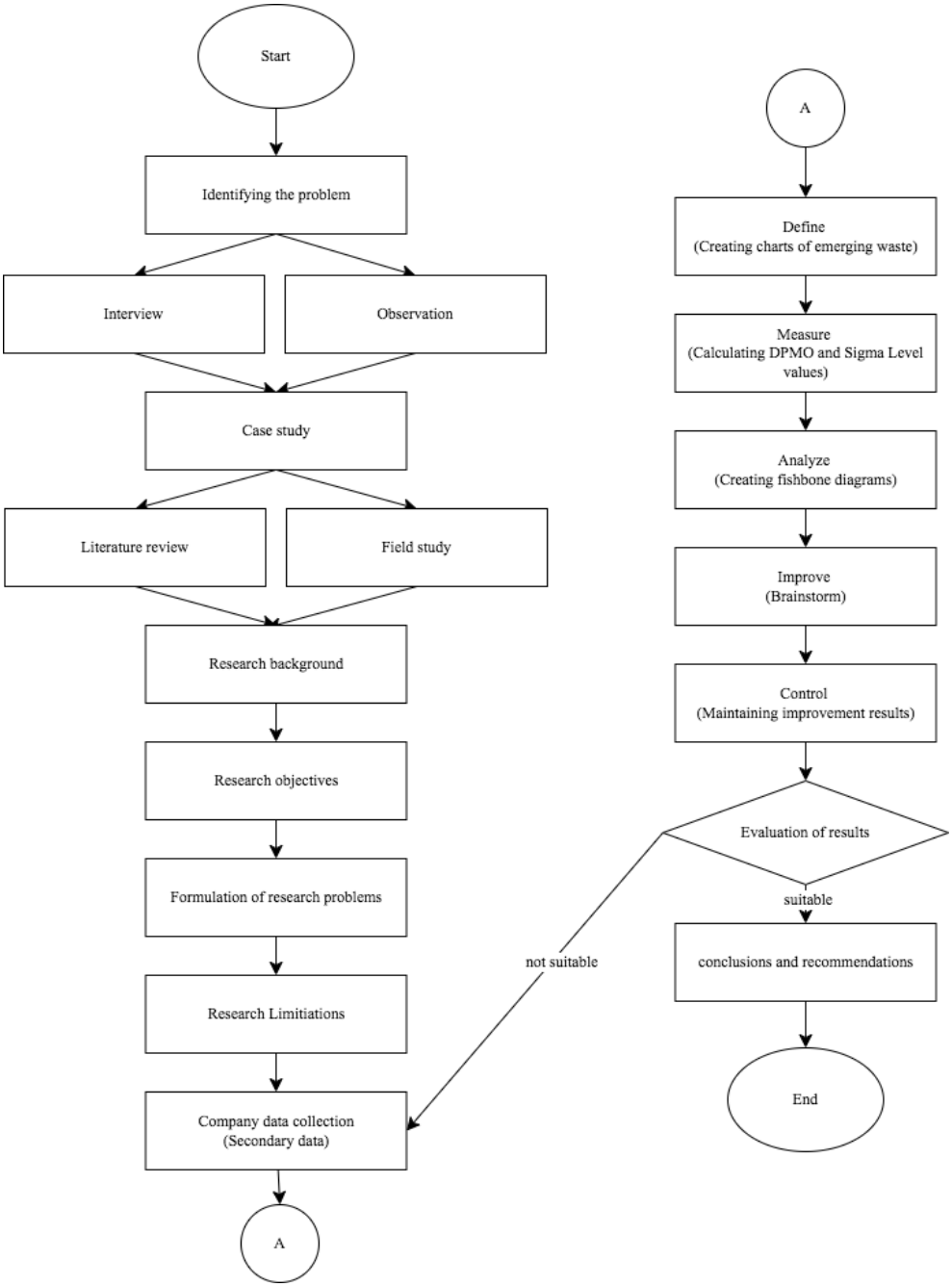

Fig. 3. Research Flowchart.

3 Results and Discussion

3.1 Data Collection

The results of field observations show that there is waste in the supply chain sector, mainly in the form of waiting time and inventory during the business process. Therefore, the data collected is information about the extent to which waste in waiting time occurs at each stage of the business process from April to July 2023. This data will be used to carry out analyses and efforts to reduce waste, especially in terms of waiting time and inventory management in company business processes.

Table 1: Emerging Waste Data (Source: Company Secondary Data for April 2023-July 2023).

Activity	**Month**	***Waste (Frequency of occurrence)***	***Success (Frequency of occurrence)***	**Total every month *(Frequency of occurrence)***	**Total *(Frequency of occurrence)***
Distribution	April	99	844	943	3893
	May	129	843	972	
	June	125	825	950	
	July	132	896	1028	
Storage	April	4	7	11	48
	May	5	8	13	
	June	4	7	11	
	July	5	8	13	
Receiving	April	4	7	11	48
	May	5	8	13	
	June	4	7	11	
	July	5	8	13	

3.2 Data Processing

Based on the stages of the DMAIC Method, which are structural steps for making improvements and eliminating waste that arises as a result of non-value-added activity, they are as follows [16]:

Define. The Define stage in the improvement process identifies the focus of waste reduction based on the number of events that occur in the three business processes [16], [17]. This incident data was obtained from the company's recapitulation. In receiving activities, the main concern is the waiting time for ships to load and unload, caused by limited space in the spherical tanks. In the Storage stage, attention is focused on excessive inventory events.

Meanwhile, in distribution, the focus is on waiting time when waiting for trucks to come to fill up LPG gas. Once waste is identified, corrective steps are taken to increase effectiveness and

efficiency in business processes. The main goal is to achieve a sigma level of 6 and a DPMO value of 3.4, indicating a very high-quality level in process management.

Based on the diagram, the waste that occurs most frequently is in distribution activities, which occurred 485 times in the last four months. This waste is in the form of the company waiting time for trucks to fill LPG gas at the filling shed. This waiting time also impacts waiting time in general and excess stock (inventory) in business processes. Therefore, improvements are needed, especially in the distribution stage. At the Define stage, the first step is to determine the most critical elements in the process (Critical to Process), which include factors that significantly impact waste and need to be considered in improvement efforts. The critical process at this stage is as follows:

a. Availability of safe stock (not excessive and not insufficient)
b. Carry out distribution at the right pick-up time
c. LPG products are received from suppliers on time

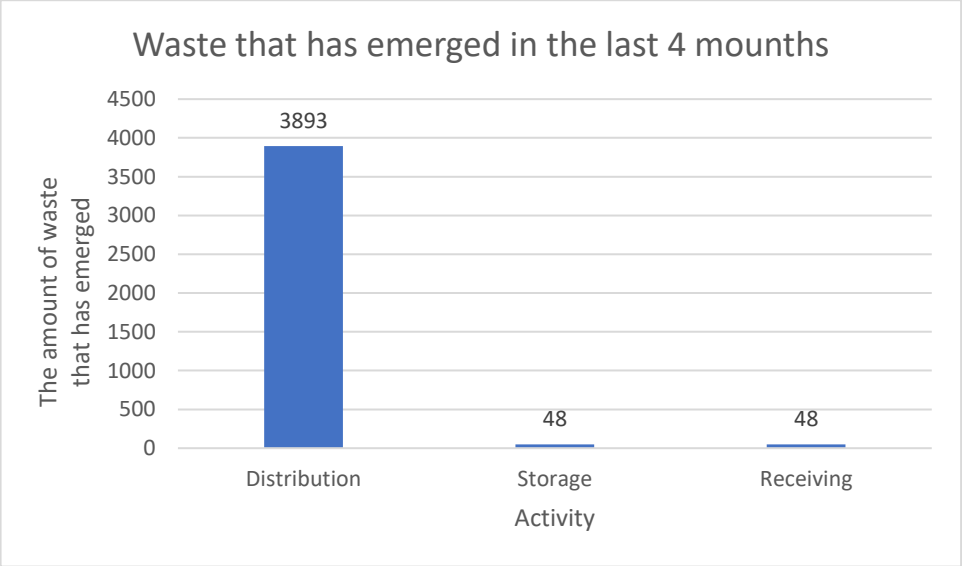

Fig. 4. Emerging Waste Graphics.

Measure. The Measure stage involves calculating the DPMO (Defects Per Million Opportunities) [16] and Sigma Level values for the last four months, carried out every month. This calculation aims to measure each business process to identify the causes of obstacles in implementing business processes. The DPMO and Sigma, Level calculation results are used as a guide for implementing corrective actions to reduce obstacles in business processes. This calculation is also used as a guide in maintaining efficient and sustainable business process control efforts. The aim is to continue improving business processes to reduce waste, aiming to reach Sigma Level 6. Sigma Level 6 indicates a quality level equivalent to world-class standards, with a meagre defect rate of 99.99966% in business processes.

Table 2: DPMO Data Processing and Sigma Levels.

Month	*Waste* emerging	Amount processed	CTQ	DPMO	Sigma Value
April	107	965	3	36960.2763	3.29
May	139	998	3	46426,1857	3.18
June	133	972	3	45610.4252	3.19
July	142	1054	3	44908.2859	3.20

The results of calculating the DPMO value and sigma level for July 2023 show that the waste that emerged during that period was 14.61%. The DPMO obtained was 44908.2859, which indicates that there is potential for instability in the business process. The sigma value obtained is 3.20, which indicates that the business process has not yet reached a high level of stability. While the numbers indicate instability and necessary improvements, there is still room for improvement.

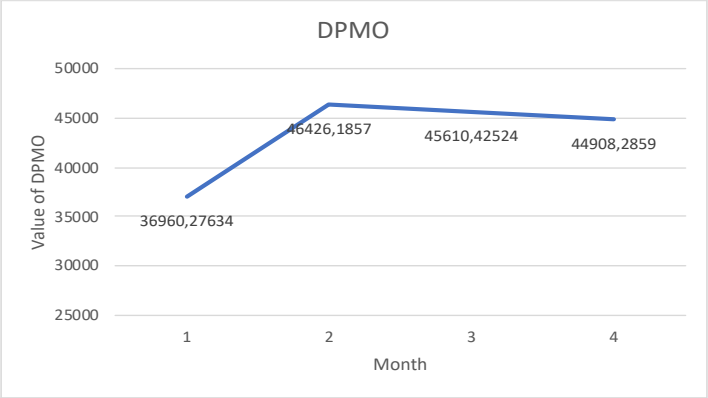

Fig. 5. Month DPMO Chart.

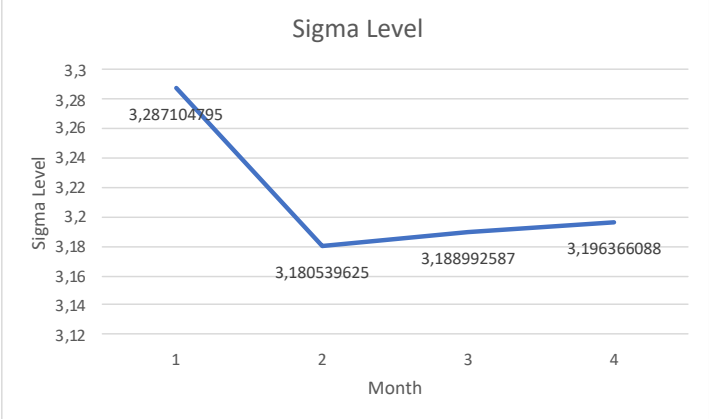

Fig. 6. Month Sigma Level Chart.

Analyze. Based on the waste that appears in the LPG business process, the problem's root was searched using a fishbone diagram by interviewing the company at LPG Operations and identifying the reasons for the delay in the arrival of the LPG tank truck (skid tank). In this fishbone diagram, we are looking for the root of the problem[13] that causes waste in the form of waiting and inventory, which is as follows:

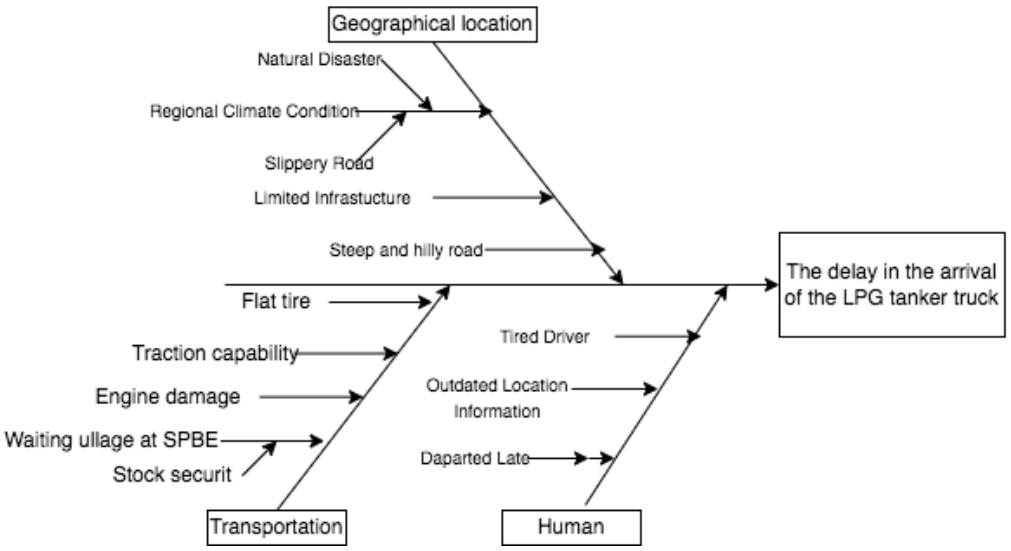

Fig. 7. Long Coming Truck Fishbone Diagram.

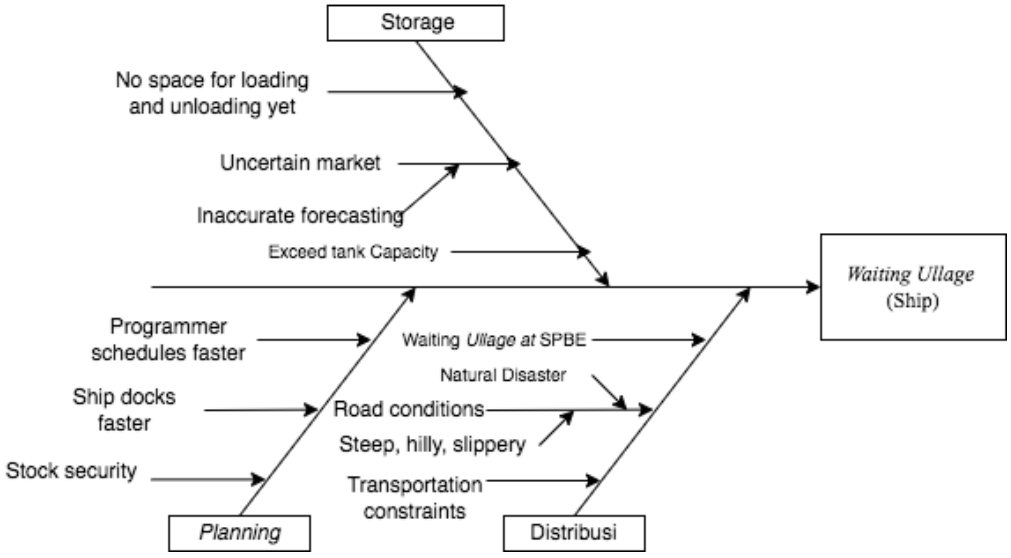

Fig. 8. Fishbone Waiting Ullage (Vessel) Diagram.

Based on the fishbone diagram, three main factors cause waiting for ullage, which must be considered in improvement efforts. The critical process at this stage is as follows:

a. Storage Factor: Limited storage capacity causes ships to wait until the LPG product stock arrives at the dock, which exceeds the available storage capacity in the Spherical Tank. For example, the remaining stock in the Spherical Tank is only 1500 MT, but the LPG products that arrive are 1700 MT. Therefore, there is a waiting time to be able to unload and create space for additional products.
b. Operational Planning Factors: Inaccurate forecasting in operational planning for LPG products is also a contributing factor. Supply security forces ships to dock sooner than planned when demand is high. This results in waiting times in business processes.
c. Transportation Obstacle Factors: The long time required for the arrival of LPG tank trucks is caused by transportation obstacles, including steep, steep, and slippery road conditions. All these factors cause waiting in the company's business processes.

Improve.

Tank Trucks Are Long Coming.

Factor	:	Man
Problem	:	The driver is tired, the location information is not current, and leaves late.
Improvements	:	1. Drivers / AMTs should get enough rest, and the company has 2 AMTs for companies that have pretty long distances in 1 trip. 2. Using GPS technology so that the company can get the actual location of the tanker 3. SPBE must arrange and predict the time so the LPG tanker can arrive at the depot at the right time. 4. Companies can carry out Clustering by paying attention to daily demand and the distance between the depot and the SPBE.
Excess	:	1. Travel time does not decrease much due to rest time. 2. The company can get the actual location, there is no need to make calls on the driver's cell phone because it will endanger the driver, and if an accident occurs to the driver and truck, the party carrying out the rescue of the LPG product can move quickly without asking for the current location. 3. The truck arrived on time. 4. The company's working time can be more optimal 5. Company operational costs in the form of overtime can be reduced
Lack	:	1. It will increase operational costs for the additional AMT, which will be charged to the SPBE. 2. The incurring investment costs for GPS installation are charged to SPBE. 3. The initial implementation requires adaptation time.
Factor	:	Geographic Location

Problem	:	Natural disasters, regional climate conditions, slippery and steep roads, limited infrastructure, long distances
Improvements	:	1. Collaborating with other SPBE parties: if the road experiences a natural disaster that makes it impossible to pick up LPG products, then this can be initiated by borrowing LPG trucks from other SPBE parties. It is also an alternative if demand at distant SPBEs is booming. 2. Ensure the condition of all truck components is functioning correctly, carry out routine maintenance, and replace trucks that have reached their economic age. 3. Adding skid tank trucks according to SPBE's daily sales/demand
Excess	:	1. Even though natural disasters and demand conditions are booming, distribution continues to be carried out. 2. Trucks will function safely in distributing LPG 3. No skid tank truck makes two trips in one day.
Lack	:	1. The availability of LPG tank trucks is not necessarily available 2. Maintenance costs are arising and being charged to SPBE. 3. There are pretty significant investment costs.
Factor	:	Transportation
Problem	:	Engine damage, flat tyres, and traction capabilities.
Improvements	:	1. The company inspects tank trucks every time they fill gas into the filling shed. 2. Ensuretyres are in excellent and safe condition and bring replacement tyres. 3. Replacing a car that has reached its economic age
Excess	:	1. Timeliness in picking up LPG gas (if clustering is carried out) 2. Reducing distribution barriers arising from trucks
Lack	:	1. High investment costs are charged to SPBE (when replacing a tanker)

Waiting Ullage (Ship).

Factor	:	Storage
Problem	:	There is no space for loading and unloading tank capacity.
Improvements	:	1. Forecasting stock receipt plans by analyzing market demand, seasonal planning 2. Optimize distribution by implementing GPS technology and logistics software. 3. Conduct weekly evaluations of LPG gas receipts.
Excess	:	1. Optimized operational costs. 2. Increased profits obtained by the company by eliminating losses resulting from excess stock
Lack	:	1. Investment costs arise due to GPS installation
Factor	:	Distribution
Problem	:	Trucks take longer to arrive, natural disasters, steep, slippery road conditions, and problems with transportation.

Improvements	:	1. Increase the effectiveness and the efficiency of the distribution process by making all efforts, such as forecasts and clusters on the SPBE side. 2. Eliminates waiting time that arises from waiting for trucks to arrive. 3. Implement a GPS to get the actual location 4. Bring spare equipment to repair tank cars that experience problems. 5. Create operational limits for LPG distribution.
Excess	:	1. The waiting time for the tanker truck is not long. 2. *Stock* will be safe (no shortage and no excess) 3. At reception, there is no waiting time for ullage
Lack	:	1. The initial implementation of LPG operational optimization will require adaptation time. 2. Investment costs from installing GPS are charged to SPBE and companies that purchase monitors.
Factor	:	Planning
Problem	:	Ship docks faster, schedule programmer faster, stock security.
Improvements	:	1. When the ship arrives, the supply depot is not immediately filled into the ship. 2. Added daily sales
Excess	:	1. LPG products are received on time with storage conditions that have sufficient space for loading and unloading ships.
Lack	:	1. The stock will not be safe if there are problems during the ship's journey.

Controls. The following are the controls carried out to monitor each improvement process so as not to cause waste that appears in business processes:

a. Tests are carried out on existing operations, and periodic evaluations must be conducted.
b. KPIs (Key Performance Indicators) are created to maintain operations so as not to cause non-value-added activity variations.
c. The monitoring control team routinely inspects improvements that have been implemented.

4 Conclusion

Based on the observations and calculations that have been carried out, the following conclusions can be drawn:

1. In the business process of PT Pertamina Patra Niaga, Teluk Kabung Integrated Terminal, two types of waste appear, namely waiting and inventory, which is used as the basis for calculating the DPMO value (Defects Per Million Opportunities) and sigma value. This waste appears in three stages of the business process: Receiving, Distribution, and Storage. In the Receiving stage, waste occurs because the ship has to wait a long time (waiting) before it can unload in the spherical tank. It is caused by several factors, such as ships arriving too quickly, the amount of LPG stock exceeding the capacity of storage tanks, and delays in tank trucks, which hamper the distribution process. Waste at the storage stage

occurs at the same time as the ship arrives because the stock exceeds the capacity of the spherical tank, and delays also influence it in LPG tank trucks. At the distribution stage, the most significant waste is tank truck waiting time. Factors such as geographic location, human factors, and problems with the truck itself influence the occurrence of this waste. Geographic factors include steep, slippery roads, limited infrastructure, natural disasters, and long distances between SPBE and LPG terminals. Human factors involve inaccurate information regarding truck locations provided by the system (AMT), resulting in waiting times. Problems with the truck, such as tyre leaks, can also cause obstacles in the LPG distribution process.

2. Based on the calculation of the DPMO value and sigma value for four months, it was found that the Teluk Kabung Integrated Terminal had an average DPMO of 3.21 and an average sigma level of 43476, which is in line with the industrial average in Indonesia. However, further steps need to be taken to eliminate waste and increase effectiveness and efficiency to achieve a DPMO value of 3.4 and a sigma level of 6. Several steps can be taken to eliminate waste in business processes, including collaborating with other SPBE parties. When facing obstacles such as natural disasters or spikes in demand, ensuring the condition of trucks is running well through routine maintenance, adding skid tank trucks according to SPBE's daily needs (although this results in investment costs), utilizing GPS technology to track truck locations with relevant investment costs, and limiting the operational hours of the Teluk Kabung LPG Depot so as not to require excessive overtime. These steps can help increase efficiency in managing waste and improve terminal performance.

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