Improvement of the Coal Inventory Management System Using the Economic Order Quantity Method

A Case Study of PT Petrokimia Gresik

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Abstract. In a business, inventory is frequently known as a source of contention. PT Petrokimia Gresik (PKG) is PT Pupuk Indonesia's (Persero) subsidiary, an agro-industry company that the government always requires to meet national fertilizer supply to ensure food security and perform more efficient and cost-effective cost savings, through more efficient and economical use of facilities and infrastructure, including inventory management. At PKG, one of the most crucial inventory management issues is coal inventories, which have lately experienced a price increase of more than 200%. The trend of global coal prices has climbed to 2 times higher since 2021. The price of coal in Indonesia has risen from Rp. 500,000 per ton to Rp. 1,500,000 per ton, not to mention the world's current state of war, the Russian invasion of Ukraine, which has *increased* fuel prices worldwide, including coal, which is in high demand by utility companies in Indonesia. While PT Petrokimia Gresik must continue to produce despite rising coal prices, inventory must be managed to achieve the lowest possible cost. Adopting the Economic Order Quantity (EOQ) method to improve the coal inventory management system needs to be considered. EOQ is an old theory, but we believe it is still relevant today. We will compare the company's current coal inventory management to the EOQ method regarding efficiency, efficacy, and expenses associated with reordering, storage, and other factors. The study concludes that PKG's coal supply system is relatively good, although there is still potential for improvement. The inventory management policies that are in place still refer to the prior period's experience. Several causes contribute to coal overstock and understock issues, including a coal supply planning system that is not yet optimal. The proposed future improvement is to employ the Economic Order Quantity (EOQ) approach, which can save Rp 684,000,000 per year (average) in inventory expenditures. This demonstrates that the EOQ approach can save 6.7% per year in costs.

Keywords: Inventory · Coal · Economic Order Quantity

1 Introduction

PT Petrokimia Gresik (PKG) is PT Pupuk Indonesia's (Persero) subsidiary, an agro-industry company that the government always requires to meet national fertilizer supply

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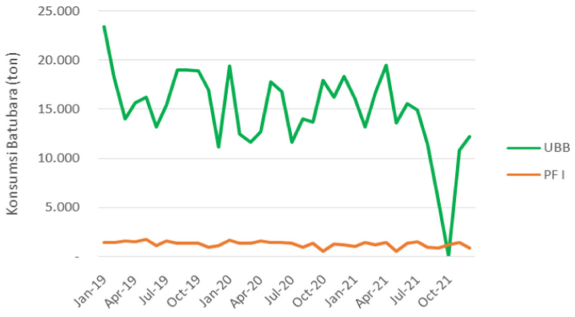

Fig. 1. PKG Coal Requirements for 2019–2021

to ensure food security and perform more efficient and cost-effective cost savings through more efficient and economical use of facilities and infrastructure, including inventory management.

PKG's inventory system is made up of numerous components, including planning, managing, and processing. These characteristics encompass various tasks, including purchasing, storage or warehousing, production, and administrative accounting. To achieve a balance of varied interests in a company, each function must be addressed with an integrated approach. Ending inventory should constantly be handled to provide the best results. Coal is one of the essential commodities used in PKG (Fig. 1).

Coal is used as a fuel to generate steam or as a heat source in the manufacturing process. PKG coal is used in two factories: the Utilitas Batubara (UBB) and the Phosphate I Fertilizer Factory (PF I).

Coal inventory management is critical, especially given the recent issue of a more than 200% increase in coal prices. The trend of global coal prices has climbed to 2 times higher since 2021. The price of coal in Indonesia has risen from Rp. 500,000 per ton to Rp. 1,500,000 per ton, not to mention the world's current state of war, namely the Russian invasion of Ukraine, which has increased fuel prices worldwide, including one type of fuel, coal, which is in high demand by utility companies in Indonesia. While PKG must continue to produce amid rising coal costs with inventory must be managed to achieve the lowest possible cost.

Due to operational issues, coal demand declined from 217,560 tons in 2019 to 198,042 tons in 2020. Because of a significant increase in coal prices in Indonesia from around Rp 800,000 to Rp 1,500,000 per ton (an increase of nearly 200%) in Semester 2 of 2021 and the scarcity of coal supply in the Kalimantan area, as well as policies from the central government to secure coal supply to the PLN group, the realization of coal use will decrease to 163,200 in 2021.

Although the use of coal in PKG decreased by 9% in 2020 and 25% in 2021, we could not use any quantitative forecasting approach (regression, moving average, etc.) to estimate coal demand in 2022 or 2023 since that year's characteristics were unique, such as the construction of new factories and the revitalization of coal units, which will increase the need for steam in the manufacturing process, and ensuring that coal consumption would rise. The demand for coal is expected to increase by 65% between

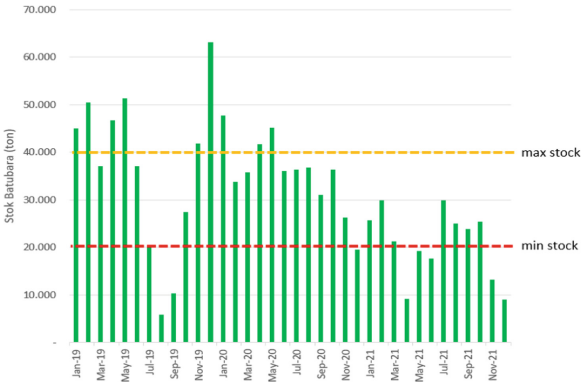

Fig. 2. PKG Coal Understock and Overstock Conditions 2019–2021

2022 and 2023. As a result, a new approach and system for controlling coal inventories at PKG are required to deal with the expected growth in the coming years.

Overstock is one of the most common operational issues. Overstock conditions are influenced by several factors, including the existence or absence of downtime in the steam user facility, the working load of the coal boiler, and the quality of the coal itself, which cannot be used if it is wet or damp. To avoid this problem, regular and frequent inventory orders are placed; nonetheless, frequent inventory orders result in cost waste.

Another issue that frequently occurs at PKG is understock inventory which happens when the amount of coal available is insufficient to meet demand. These conditions can impair plant operations, and it is not out of the question that the plant will be shut down due to a lack of steam or a lack of thermal energy sources due to the lack of coal stock.

Figure 2 depicts the occurrence of coal understock and overstock at PKG over three years (2019–2021). It can be observed from Fig. 2 that coal understock is relatively common over the 2019–2021 period. In 2019, there was one occurrence of understocking, and in 2020, there was none. However, by 2021, the occurrence of understock was doubled. Understock conditions have become more common in recent years. Yet, they can still reduce the Coal Utility unit's service level to its service customers, such as production units and other stakeholders.

Overstock events frequently occurred, as many as 12 times, 3 times, and 0 occasions in 2019, 2020, and 2021, respectively. Even though the trend has been downward for the last three years, it is vital to plan ahead and manage carefully to keep the coal stock at a safe level. Developed and developing countries have implemented inventory management utilizing the Economic Order Quantity (EOQ) method in both the public and private sectors. According to Vikaliana [1], EOQ is an inventory control method in which goods are ordered in fixed quantities to reduce inventory costs. EOQ can lower inventory expenses by lowering purchasing, storage, and procurement costs.

EOQ is an old idea, but we believe it is still relevant today. The traditional EOQ model aims to maximize overall profits (or minimize the total cost) by saving production and operational costs without significantly increasing production input, especially for cost and profit optimization in logistics and inventory phases [2, 3]. The model assumes that (annual) demand is constant [4, 5].

Among the different ways available, the researchers chose the EOQ method because it is straightforward and can solve various inventory issues that frequently arise in manufacturing organizations, such as PKG, as described above. EOQ is used in businesses to determine the most efficient and effective ordering quantity. Then, based on the inventory utilization pattern, determine the reorder point when the work unit must place another inventory order. This technique can also be adjusted with many company-specific rules, such as good and service procurement provisions. The supply contract is fulfilled multiple times, and the delivery clause is fulfilled multiple times. Based on the above description, the authors aim to know how the EOQ inventory system's design may minimize inventory costs when applied to PKG, and then study and compare the outcomes.

2 Research Methods

The study was carried out with a qualitative approach. The case study methodology utilized in this work has various advantages, including examining one to several issue objects for further analysis that can be simple or complicated (cross-case analysis). This study employed observation, interviews, and documentation as a data-gathering tool. The following were the data collection procedures used in this study: (1) Observation, (2) Depth Interview, and (3) Documentation.

The data for this study came from both primary and secondary sources. Primary data was gathered through direct observation and interviews with PT Petrokimia Gresik employees (SVP Technology, VP Production Planning & Energy Management, VP Supervision and Planning of Goods and Services, AVP Factory Production 3, AVP Coal Utilities, Staff Dep. Supervision and Planning Goods and Services, Staff of the Department of Procurement of Goods, and Staff of the Department of Accounting). Secondary data was gathered by examining supporting documents and other sources (literature), such as reports on coal inventory positions and vendor coal price data. Figure 3 shows conceptual framework of this study.

The following are some of the calculation analysis variables that allow the usage of the EOQ method:

1. Economic Order Quantity (EOQ)
   The EOQ is the value of the amount of material required for each purchase at the most cost-effective price. EOQ is calculated using the formula:

$$EOQ = \sqrt{\frac{2 \times D \times S}{H}} \tag{1}$$

   Note:

   D : Coal requirement per year
   S : Ordering cost per order
   H : Holding cost per unit

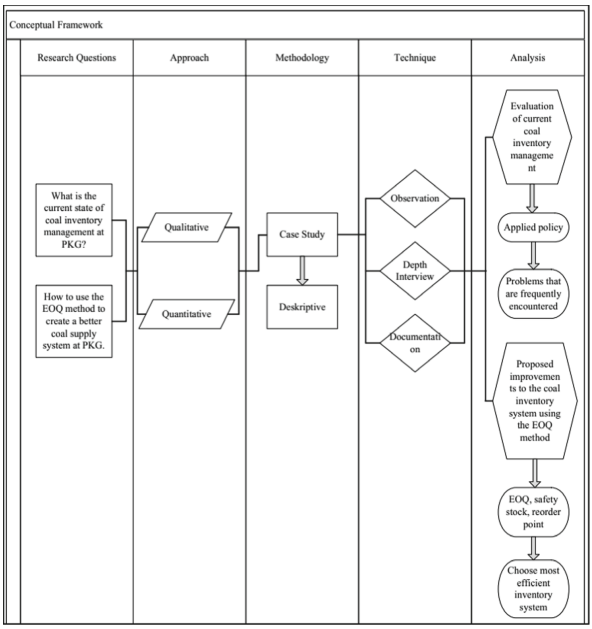

Fig. 3. Conceptual Framework

2. Total Inventory Cost (TIC)
   Total inventory cost is a calculation of total raw material inventory used to see if the EOQ method of calculating inventory purchases is better than the company's traditional method. The formula for calculating TIC is as follows:

$$TIC = \sqrt{2 \times D \times S \times H} \tag{2}$$

   Note:

   D : Demand needed
   S : Ordering cost
   H : Holding cost per unit

3. Safety Stock (SS)
   Safety stock is a good way to protect the company from any inventory-related dangers. The size of the divergence from the average over the previous several months is used to calculate the safety stock. The standard deviation is determined as follows:

$$Standard\ Deviation = \sqrt{\frac{\sum (X - x)^2}{n}} \tag{3}$$

   Note:

   n : number of data

X : coal requirement
x : average coal requirement

4. Maximum Inventory (MI)
The organization requires maximum inventory to ensure that the amount of inventory in the warehouse is not excessive and that no working capital is wasted. Maximum Inventory is calculated using the following formula:

$$MI = SS + EOQ \tag{4}$$

5. Reorder Point (ROP)
The Reorder Point (ROP) is used to keep track of inventory items so that when things are returned, they arrive on time. ROP is calculated using the following formula:

$$ROP = SS + (\mathrm{LT} \times \mathrm{Q}) \tag{5}$$

Note:

LT : Lead Time
Q : average coal consumption per day

3 Results and Discussion

PKG manages its coal stock by attempting to keep it in a secure position. Typically, inventory is kept at a level that allows it to satisfy operating needs for at least one month; however, a reorder point is established if the stock is just one month away. Until now, the coal inventory monitoring system has been carried out manually. The inventory report at the end of each month, which describes the position of the coal stock at the beginning and end of the month, is used to keep track of inventory. A reorder of coal will be placed with the procurement partner, namely the PPBJ Department and the Goods Procurement Department, if the stock is deemed sufficient for operating activities next month.

Due to many causes, this mechanism can sometimes create delays in the shipment of coal, resulting in a shortage due to many factors: (1) Lead time, or the time it takes for coal to arrive at the company, varies; it might be inaccurate to forecast how long it will take if it is not adequately monitored. (2) The lengthy procurement procedure, particularly the issuance of PRs (Purchase Requests). (3) With this manual system, human error can arise due to negligence of the individuals or staff who manage it, resulting in error warnings or recording errors. EOQ calculations were performed in this study utilizing data from the previous three years, starting in 2019, 2020, and 2021. Table 1 shows data on coal demand over the last three years.

Table 1 exhibits that the coal in PKG is used at UBB and PF I Plant with a total demand of 163,200–217,560 tons per year and an order frequency of 21–34 times. Table 2 shows the breakdown of the costs associated with placing an order.

Shipping costs, administrative costs, and supervision fees for arriving goods are all included in the ordering fee. These types of costs are considered when determining how much money can be saved utilizing the EOQ method. Table 3 shows the storage expenses in detail.

Table 1. Coal Ordering Frequency 2019–2021

Year	Plant	Coal Required (ton)	Ordering Frequency
2019	UBB	201.012	
	PF I	16.547	
	Total	217.560	34
2020	UBB	182.600	
	PF I	15.442	
	Total	198.042	21
2021	UBB	149.484	
	PF I	13.716	
	Total	163.200	22

Table 2. Ordering Cost 2019–2021

Year	Ordering Cost (Rp Million)
	S
2019	259
2020	374
2021	288

Table 3. Holding Cost 2019–2021

Year	Holding Cost Per Unit (Rp Million/ton)
	H
2019	30.217
2020	41.868
2021	31.995

Utility costs (electricity and water), personnel and handling costs, and warehouse cleaning fees are all included in storage prices. The computation of corporate policies is shown in Table 4. Table 4 illustrates PKG's coal purchases from 2019 to 2021, with an average order frequency of 26 orders per year.

Table 5 displays the results of utilizing the EOQ method to calculate data. According to Table 5, the frequency of orders placed by PKG has decreased from 26 to 3–4 times a year. The EOQ method of calculating the total inventory cost tries to identify the efficiency value that can be generated when the company's inventory size is optimized.

Table 4. Calculation of Existing Condition 2019–2021

Year	Plant	Coal Required (ton/year)	Frequency	Average Order (ton)
		D	f	Q = D/f
2019	UBB	201.012		
	PF I	16.547		
	Total	217.560	34	6.399
2020	UBB	182.600		
	PF I	15.442		
	Total	198.042	21	9.431
2021	UBB	149.484		
	PF I	13.716		
	Total	163.200	22	7.418

Table 5. Calculation Based on EOQ Model 2019–2021

Year	Plant	EOQ $\sqrt{\frac{2\times D\times S}{H}}$	Frequency $f = \frac{D}{EOQ}$
2019	UBB	56.654	
	PF I	4.664	
	Total	61.318	4
2020	UBB	57.945	
	PF I	4.900	
	Total	62.845	3
2021	UBB	52.568	
	PF I	4.824	
	Total	57.392	3

Table 6 shows the complete computation results. According to Table 6, coal inventory control at PKG is deemed possible to perform using the EOQ approach. Companies can reduce the amount of money they spend on coal inventory. The EOQ method can be used to calculate overall inventory costs and give cost efficiency.

PKG has budgeted for a reasonable amount of safety stock for coal. The company's safety stock is currently 20.000 tons. The acceptable tolerance level is set at 5%, while the service ratio is set at 95%, resulting in a safety factor of 1.65. The safety stock calculation based on EOQ is 6.983 tons. PKG has calculated the maximum inventory

Table 6. Saving of Total Inventory Cost 2019–2021

Year	Existing (Rp Million)	EOQ (Rp Million)	Saving (Rp Million)
2019	10.761	9.911	850
2020	11.413	10.682	730
2021	8.147	7.675	472

Table 7. Maximum Inventory Calculation 2019–2021

Year	Safety Stock	EOQ	Maximum Inventory
2019	5.209	61.318	66.527
2020	4.476	62.845	67.321
2021	9.363	57.392	66.755

Table 8. Reorder Point Calculation 2019–2021

Year	D	Q/day	Lead Time	SS	ROP
2019	217.560	659	30	5.209	24.979
2020	198.042	600	30	4.476	22.476
2021	163.200	494	30	9.363	24.183

for coal based on the average amount of coal ordered plus safety stock thus far. The goal of estimating the maximum inventory is to ensure that the organization avoids shortages or surplus inventories, as both can cause significant disruptions in the production and distribution processes, as well as financial losses. Table 7 shows the maximum inventory using EOQ.

The Reorder Point (ROP) is used to keep track of inventory items so that when it is time to reorder, the goods will arrive on time. PKG sets reorder points based on time and the projected demand, ensuring that reorders are placed when the warehouse inventory begins to feel low. The EOQ method is used to calculate reorder points, as shown in Table 8.

4 Conclusion

Several things can be deduced based on the research's primary objective as well as the results of the analysis and debate conducted in the preceding chapter, including:

1. Currently, PKG's coal inventory management is as follows: (a) The inventory system is adequate yet insufficient. (b) The management system policies in place are still

based on the practices agreed upon by management based on the previous years' experience.
2. The Economic Order Quantity (EOQ) technique can save Rp 850 million in 2019; Rp 730 million in 2020; and Rp 472 million in 2021 in inventory expenditures.

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