Economic Order Quantity and Reorder Point Optimize Air Compressor Spare Parts Inventory

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Abstract. General Background: Effective inventory management is essential for ensuring production continuity while minimizing excess stock, operational costs, and warehouse inefficiencies. Specific Background: At PT. XYZ, increased imports of air compressor spare parts, particularly Oil Engine Separators, led to stock accumulation due to ordering quantities exceeding storage capacity. Knowledge Gap: However, limited application of systematic inventory control methods has resulted in inefficiencies in determining optimal order quantities and reorder timing. Aims: This study aims to determine the optimal quantity of compressor spare parts using the Economic Order Quantity (EOQ) and Reorder Point (ROP) methods. Results: The findings indicate that the application of EOQ and ROP significantly reduces inventory costs from Rp. 322,362,150 to Rp. 33,020,408, resulting in cost savings of Rp. 289,341,742 and reducing stock accumulation in the warehouse. Novelty: This study demonstrates the combined application of EOQ and ROP methods in managing air compressor spare parts inventory within a real industrial context. Implications: The results provide practical guidance for companies to optimize inventory control, reduce operational costs, and prevent overstocking through structured inventory management approaches.

Keywords: Economic order quantity; Reorder point; Inventory management; Spare parts inventory; Cost optimization

1 Introduction

Procurement plays a significant role in the business journey of a company. Companies, whether trading or manufacturing industries, often prioritize inventory as a company asset. Inventory is the amount of goods stored and available for sale to consumers at a certain time or period [1]. Good spare parts inventory can be achieved by planning, implementing, and monitoring spare parts inventory to determine the spare parts needed by the company and to achieve optimal efficiency and effectiveness in the warehouse as well as ensure smooth operations. This can happen if proper maintenance work can be carried out so that it can be implemented properly [2].

PT. XYZ is a leading shoe company known for producing the highest quality shoes. The current issue is a lack of understanding regarding the purchasing pattern for *Air Compressor* spare parts that are ordered simultaneously. In 2022, PT. XYZ imported 54 *oil engine separators*, and in 2023, it imported another 66 similar *spare parts*. This number has increased by about 10% from the previous year. This has led to a backlog

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of *spare parts* in the warehouse because the number of orders exceeds the warehouse capacity. Production planning needs to be accompanied by efficient stock management. Available stock must always be sufficient so as not to hinder the production process, enabling the company to continue to meet customer demand [3]. Setting inventory levels is crucial for a company because it directly affects profits. Errors in determining the amount of goods stored can have an impact on the company's final financial results. Therefore, it is recommended that companies successfully determine the optimal and cost-effective inventory level so that total inventory expenditure can remain at a minimum cost [4].

A shortage of components in a machine can potentially delay or even halt production, resulting in costs. An excess of materials can potentially cause damage to materials and increase storage costs. Delays in ordering spare parts from *suppliers* can result in delays in the arrival of components and other problems [5]. Companies need to find a balance between the allocation of funds for stock and customer satisfaction levels. Inventory management is a crucial aspect of achieving sustainable competitive advantage. [6]. Preparing machine spare parts must be carried out so that when there are problems with machine parts in production, repairs and replacements can be carried out immediately so as not to disrupt production for a long time. However, the supplies that are procured can also cause problems. A low *inventory turnover* (ITO*)* rate can result in the accumulation of goods in the warehouse [7].

One step that can be taken to support production activities in a company is through the implementation of scheduled raw material procurement and adjusting to company decisions. In addition, companies also need to plan and control existing inventory in order to reduce expenses and increase profits. Generally, inventory management models aim to reduce total costs, which include *ordering costs* and *holding costs*. Since other costs, such as production inventory costs, are usually fixed, reducing either ordering costs or holding costs directly impacts the reduction of total costs [8].

Raw material inventory management is an effort to monitor or ensure that raw materials are readily available. In addition to production scheduling, proper inventory management is also required in carrying out the production process [9]. Raw material management can be used as a method to determine the timing of orders to increase raw material stock and the quantity of raw materials ordered [10]. By implementing a raw material management policy within the company, inventory costs can be reduced to the lowest level. One step that can be taken to reduce storage costs is through *Economic Order Quantity* (EOQ) analysis. EOQ refers to the most efficient order quantity for each transaction [11]. The purpose of this study is to determine the optimal ordering rhythm for *compressor* machine components using the EOQ method so as to produce minimum *error* for each ordering period. It is hoped that after conducting this research, it will be possible to control excess spare parts in the warehouse and reduce procurement and storage costs.

2 Method

2.1 Research Time and Place

This research was conducted at PT. XYZ, located in the Sidoarjo area. The research was conducted over a period of 6 months, from October 2023 to March 2024. The information collection process was carried out through direct observation at the company and interviews with reliable sources to obtain a realistic picture of the conditions at the company. The data used in this research was obtained from historical data and literature studies from books and journals.

2.2 Research Flow

The activities during the research process are outlined in a *flowchart*, as shown in Figure 1 below

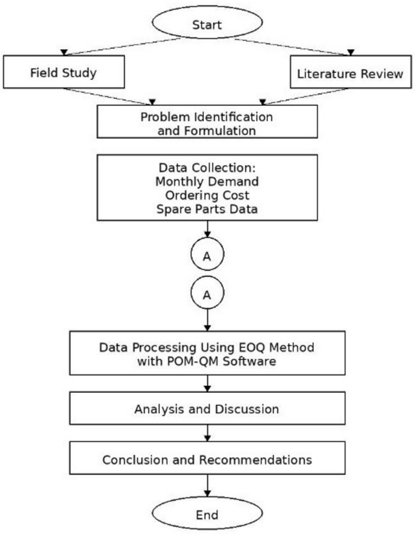


Fig.1. Research Flowchart

The steps to be carried out in this research include:

Presentation of theories
The various supporting theories are derived from reliable references such as books and journals related to inventory control, particularly the selection of methods in this study

Data collection
The data required is *the* annual *demand*, spare part costs which include ordering costs, per-item costs and *inventory* costs, as well as *spare part* requirements data calculated from 2022 to 2023. In table 1

Table 1. *Spare Parts* Requirements for 2023

Period 2023	***Filter Kit Compressor***			**Total**
	Atlas Copco	***Hitachi***	***Baldor Tech***	
January	4	0	0	4
February	5	0	1	6
March	5	1	0	6
April	4	0	1	5
May	3	0	0	3
June	4	1	1	6
July	6	0	0	6
August	4	0	1	5
September	6	1	0	7
October	4	0	1	5
November	5	0	0	5
December	6	1	1	8
Total	56	4	6	66

Table 2. Holding Cost

Holding Cost (per year)	
Electricity Exhaust	Rp 12,484,800
Lighting Electricity	Rp 3,600,000
Total per year	IDR 16,084,800
Average per unit	Rp 243,709

Table 3. Ordering Cost.

***Ordering Cost* (per order)**	
Communication	Rp 750,000
Services	IDR 2,793,875
total *per unit*	Rp 3,543,875

Table 4. *Unit Cost.*

Unit Cost	
Atlas Copco Filter Kit	Rp 8,540,000
Hitachi Filter Kit	IDR 7,982,501
Baldor Tech Filter Kit	IDR 5,692,000

Data processing

The collected data were further processed using Microsoft Excel and POM-QM software to determine the optimal quantity of compressor spare parts required and to minimize ordering errors in each order period. The demand data used in the calculation were obtained from the spare parts requirements presented in Table 1, which shows the monthly needs for Atlas Copco, Hitachi, and Baldor Tech filter kits during 2023. The holding cost data in Table 2 were used to calculate the annual storage cost and the average holding cost per unit, while the ordering cost data in Table 3 were used to determine the cost incurred for each order. These data were then analyzed to obtain the most efficient inventory planning results.

Drawing conclusions

After the data processing results were obtained and analyzed, conclusions were drawn based on the spare parts demand pattern in Table 1, the holding cost calculation in Table 2, and the ordering cost calculation in Table 3 and Table 4. The conclusions explain the optimal inventory decision for compressor spare parts and provide recommendations to reduce excess stock, avoid shortages, and improve ordering efficiency.

2.3 Economic Order Quantity (EOQ)

The EOQ method is a step for companies to obtain raw material stocks and determine the most efficient order quantity for each purchase based on how often and when reorders have been set. The purpose of EOQ is to identify the ideal order quantity so that companies can reduce inventory-related costs [12]. The reasons for determining raw material and finished product inventory in line with the EOQ principle are as follows: a) To overcome uncertainty in orders, given that customer demand can vary, so as to maintain customer satisfaction (e.g., to meet delivery deadlines). b) To prevent production stoppages caused by machine breakdowns, raw material problems, material shortages, and delays in raw material deliveries. c) To increase profits through various available discounts. d) To prepare for future increases [13]. The EOQ method is a formula used to determine the number of orders to minimize inventory costs. Below is the EOQ method formula:

$$\text{EOQ} = \sqrt{\frac{2 \times Co \times D}{Ch}} \tag{1}$$

Explanation:
EOQ = optimal purchase quantity (*units*)
Co = cost per order
D = quantity per user per year
Ch = storage cost per *unit* per year

The following formula is used to determine the *total inventory cost* (TIC):

$$\text{TIC} = \left(\frac{D}{Q}S\right) + \left(\frac{Q}{2}H\right) \tag{2}$$

Explanation
Q = average purchase of raw materials
D = annual demand in *units* for inventory items
S = ordering cost per order
H = storage cost per *unit* per period

Then, after finding *the total inventory cost*, you can find the number of orders (P) during the selected period using the following formula:

$$P = \frac{D}{EOQ} \tag{3}$$

Explanation
P = frequency of orders per year
D = quantity of demand in a specific period
EOQ = economic quantity of goods per order

***Reorder Point* (ROP)**

Reorder Point (ROP) is the moment when a company must place a new order [14]. Reordering can be defined as the point or condition at which a new order must be placed so that the ordered goods are received when the safety stock reaches zero to avoid stockouts [15]. The formula for calculating reordering is as follows:

$$\text{ROP} = (\text{LT} \times \text{AU}) + \text{SS} \tag{4}$$

Description:
ROP = *reorder point*
LT = *lead time*
AU = *average usage*
SS = *safety stock*

3 Results and Discussion

Using the Economic Order Quantity (EOQ) approach, inventory stock can be managed more economically by determining the optimal order quantity and minimizing total inventory costs. The EOQ calculation was carried out using Microsoft Excel and POM-QM software. The total inventory cost based on the company policy for the Atlas Copco brand is presented in Table 5, showing a total annual demand of 56 units with a total inventory cost of IDR 56,174,209. Meanwhile, Table 6 presents the total inventory cost for the Hitachi brand, with an annual demand of 4 units and a total inventory cost of IDR 15,150,336. The total inventory cost for the Baldor Tech brand is shown in Table 7, with an annual demand of 6 units and a total inventory cost of IDR 22,725,505. Furthermore, Table 8 summarizes the company's inventory cost components for each compressor brand, including annual demand, unit cost, holding cost per unit, and ordering cost per unit. These tables provide the basis for comparing the company's existing inventory policy with the EOQ calculation results.

Table 5. Total Costs Based on Company Policy for *the Atlas Copco Brand* .

Period	*Demand*	TIC
January	4	Rp 4,518,711
February	5	IDR 4,762,420
March	5	IDR 4,762,420
April	4	IDR 4,518,711
May	3	IDR 4,275,002
June	4	IDR 4,518,711
July	6	IDR 5,006,130
August	4	IDR 4,518,711
September	6	IDR 5,006,130
October	4	IDR 4,518,711
November	5	IDR 4,762,420
December	6	IDR 5,006,130
Total	56	**Rp 56,174,209**

Table 6. Total Costs Based on Company Policy for *the Hitachi Brand*

Period	*Demand*	TIC
January	0	Rp -
February	0	Rp
March	1	Rp 3,787,584
April	0	IDR -
May	0	Rp
June	1	IDR 3,787,584
July	0	IDR -

August	0	Rp
September	1	Rp 3,787,584
October	0	IDR -
November	0	Rp
December	1	IDR 3,787,584
Total	4	**15,150,336**

Table 7. Total Costs Based on Company Policy for *the Baldor Tech Brand.*

Period	*Demand*	TIC	
January	0	Rp	-
February	1	IDR	3,787,584
March	0	IDR	-
April	1	IDR	3,787,584
May	0	Rp	-
June	1	Rp	3,787,584
July	0	IDR	-
August	1	IDR	3,787,584
September	0	IDR	-
October	1	Rp	3,787,584
November	0	IDR	-
December	1	IDR	3,787,584
Total	6	**Rp**	**22,725,505**

The following are the inventory costs that have been determined by the company after calculating the monthly average.

Table 8. Total Costs Based on Company Policy for each *Compressor Brand.*

Item	*Demand*	*Unit Cost*	*Holding Cost/unit*	*Ordering Cost/unit*
atlas copco	56	Rp 8,540,000	IDR 243,709	IDR 3,543,875
Hitachi	4	IDR 7,982,501	IDR 243,709	IDR 3,543,875
Baldor Tech	6	IDR 5,692,000	IDR 243,709	IDR 3,543,875

3.1 Calculating *Economic Order Quantity* (EOQ)

Below is the calculation of the order quantity *for spare parts* in the form of Filter Kits from *the brands Atlas Copco, Hitachi, and Baldor Tech* using the *Economic Order Quantity* (EOQ) method.

$$\mathrm{EOQ} = \sqrt{\frac{2 \times Co \times D}{Ch}}$$

$$\mathrm{EOQ}(Atlas\ Copco) = \sqrt{\frac{2 \times 3.543.875 \times 56}{243.709}} = 40{,}36 \approx 41\ Sparepart$$

Based on the EOQ method calculation, the order quantity for each order of *Atlas Copco Filter Kits* is 41 *spare parts*.

$$\mathrm{EOQ}(Hitachi) = \sqrt{\frac{2 \times 3.543.875 \times 4}{243.709}} = 10{,}79 \approx 11\ Sparepart$$

Based on the EOQ method calculation, the order quantity for each order of *Hitachi Filter Kits* is 11 *spare parts*.

$$\mathrm{EOQ}(Baldor\ Tech) = \sqrt{\frac{2 \times 3.543.875 \times 6}{243.709}} = 13{,}21 \approx 14\ Sparepart$$

Based on the EOQ method calculation, the order quantity for each *Baldor Tech Filter Kit* order is 14 *spare parts*.

3.2 Calculating Order Frequency

After determining the order quantity, the frequency is calculated as follows:

$$P = \frac{D}{EOQ}$$

$$P(Atlas\ Copco) = \frac{56}{40{,}36} = 1{,}39 \approx 2 \text{ kali pemesanan}$$

$$P(Hitachi) = \frac{4}{10{,}79} = 0{,}37 \approx 1 \text{ kali pemesanan}$$

$$P(Baldor\ Tech) = \frac{6}{13{,}21} = 0{,}45 \approx 1 \text{ kali pemesanan}$$

The result of the optimal frequency calculation is 2 orders for *Atlas Copco Filter Kits*, 1 order for *Hitachi Filter Kits*, and 1 order for *Baldor Tech Filter Kits* per year. This differs from company policy because if the company uses the EOQ method, it will result in savings on ordering costs, making the total inventory costs much more economical.

4 Calculating the Reorder Point

To determine when to place a reorder, also known as *the reorder point*, *the average usage* must be calculated. This is obtained by dividing *the* total *demand* over one year by the number of operating days in a year, which is 365 days. Orders are placed using a 14-day *pre-order* system, and no *safety stock* is required.

$$\mathrm{ROP} = (\mathrm{LT} \times \mathrm{AU}) + \mathrm{SS}$$

$$\mathrm{ROP}(Atlas\ Copco) = (14 \times 1{,}39) + 0 = 2{,}15 \approx 3\ sparepart$$

The reorder point calculation for *Atlas Copco* is 2.15, which means that the company must reorder when there are 3 *Filter Kits* left in stock.

$$\mathrm{ROP}(Hitachi) = (14 \times 0{,}37) + 0 = 0{,}15 \approx 1\ sparepart$$

The reorder point calculation for *Hitachi* is 0.15, which means the company must reorder when there are 1 *Filter Kit* left in stock.

$$\mathrm{ROP}(Baldor\ Tech) = (14 \times 0{,}45) + 0 = 0{,}23 \approx 1\ sparepart$$

The calculation for the reorder point is 0.23 for *Baldor Tech,* which means the company must reorder when there are 1 *Filter Kit* left in stock.
Using the same calculation steps, the following data was obtained:

Table 9. Calculation Results for Each Brand.

Item	EOQ	Frequency	ROP
Atlas Copco	40.36	1.39	2.15
Hitachi	10.79	0.37	0.15
Baldor Tech	13.21	0.45	0.23

Inventory control was carried out using POM-QM software through the Inventory Module by selecting the Economic Order Quantity Model option. After the EOQ model was selected, the data name and inventory cost components were entered into the software according to the calculation requirements. The input data used in this stage are presented in Table 9, while the POM-QM input display for the EOQ calculation process is shown in Figure 2. This step was conducted to obtain the optimal order quantity and total inventory cost for each compressor spare part brand.

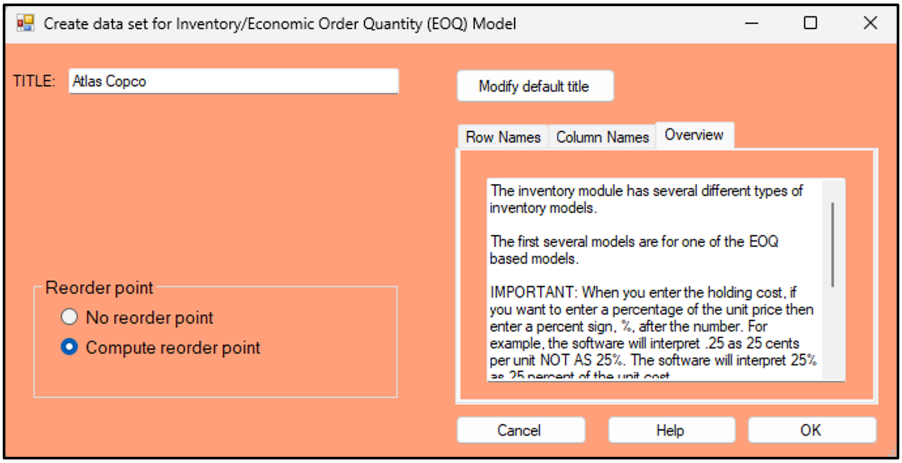


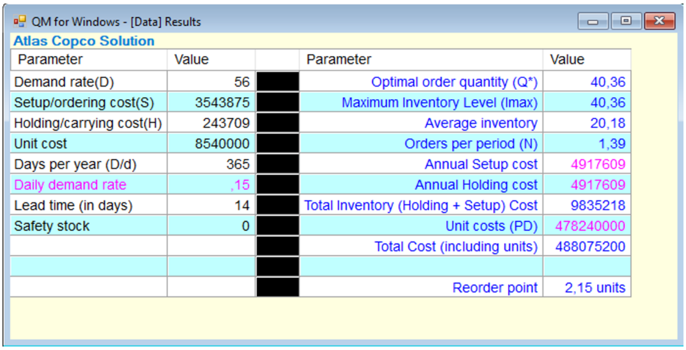
Fig.2. Create POM-QM Data.

Then click OK and enter all the data to be calculated:

Atlas Copco	
Parameter	Value
Demand rate(D)	56
Setup/ordering cost(S)	3543875
Holding/carrying cost(H)	243709
Unit cost	8540000
Days per year or ...	365
...Daily demand rate(d)	0
Lead time (in days)	14
Safety stock	0

Fig.3. Input Data

After all parameter constraints are entered, click Solve on the menu bar. The results of the EOQ model calculation will output the inventory solution Figure 4.



QM for Windows - [Data] Results

Atlas Copco Solution

Parameter	Value	Parameter	Value
Demand rate(D)	56	Optimal order quantity (Q*)	40,36
Setup/ordering cost(S)	3543875	Maximum Inventory Level (Imax)	40,36
Holding/carrying cost(H)	243709	Average inventory	20,18
Unit cost	8540000	Orders per period (N)	1,39
Days per year (D/d)	365	Annual Setup cost	4917609
Daily demand rate	,15	Annual Holding cost	4917609
Lead time (in days)	14	Total Inventory (Holding + Setup) Cost	9835218
Safety stock	0	Unit costs (PD)	478240000
		Total Cost (including units)	488075200
		Reorder point	2,15 units

Fig. 4. Inventory Solution Output

Based on the results obtained from the POM-QM output, it can be further explained as follows:

1. The optimal order quantity (Q*) or the most economical number of spare parts ordered has the same result as the Maximum Inventory Level (Imax), which is 40.36 or rounded up to 41 spare parts.
2. The average inventory, which is obtained from the value of Q/2, has a value of 20.18, rounded to 21 spare parts.
3. Orders per period (N) is a frequency value of 1.39, which means that orders are placed once a year.
4. The Annual Setup Cost and Annual Holding Cost have the same value of Rp. 4,917,609 with a Total Inventory Cost (TIC) of Rp. 9,835,218.

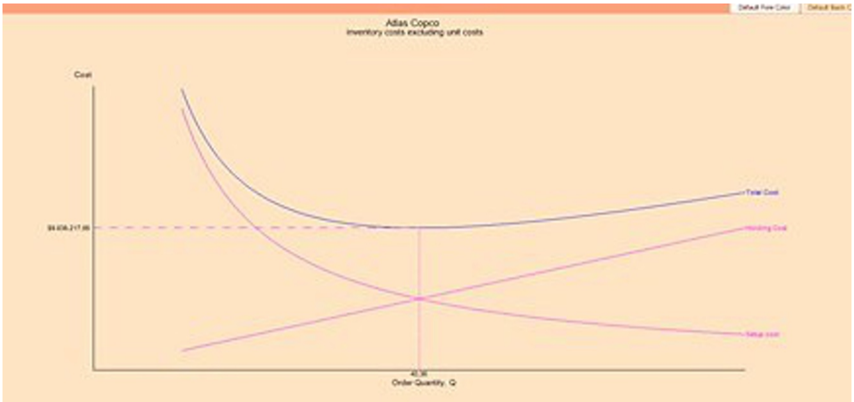


Fig. 5. Cost Curve Output

The output graph for Atlas Copco brand spare parts, as shown in Figure 3, indicates that the lowest total cost curve occurs at the intersection between the ideal order quantity and the total inventory cost. This intersection point on the x-axis and y-axis shows that the optimal order quantity is 41 spare parts per ordetabler, which can reduce company expenses by IDR 9,835,218. Furthermore, Figure 4 **and** Figure 5 present the EOQ output graphs for the Hitachi and Baldor Tech brands, showing the relationship between ordering cost, holding cost, total cost, and optimal order quantity for each spare part brand. In the EOQ model, when the holding cost increases, the ordering cost tends to decrease, and vice versa, until the most economical order quantity is reached. Therefore, the cost comparison obtained from the EOQ calculation and the company policy is presented in Table 10**.**

Table 10. Comparison of current costs using the EOQ method

Comparison	**Atlas Copco Filter Kit**		**TIC**
	Holding Cost	***Ordering Cost***	
Current Conditions	IDR 13,647,709	IDR 42,526,500	Rp 56,174,209
EOQ Proposal	IDR 4,917,609	IDR 4,917,609	IDR 9,835,218
	Difference		**Rp 46,338,991**
Current Conditions	Rp 974,836	IDR 14,175,500	IDR 15,150,336
EOQ Proposal	Rp 1,314,286	Rp 1,314,286	Rp 2,628,572
	Difference		**Rp 12,521,764**

Comparison	**Baldor Tech Filter Kit**		**TIC**
	Holding Cost	***Ordering Cost***	
Current Conditions	IDR 1,462,255	IDR 21,263,250	IDR 22,725,505
EOQ Proposal	IDR 1,609,665	IDR 1,609,665	IDR 3,219,330
	Difference		**Rp 19,506,175**

5 Conclusion

Based on the findings of the calculations conducted using the *Economic Order Quantity* (EOQ) method, it can significantly minimize expenditure costs for all three *spare part brands*. For *Atlas Copco*, total inventory costs decreased from Rp. 56,174,209 to Rp. 9,835,218, resulting in savings of Rp. 46,338,991. For *Hitachi spare parts*, inventory costs decreased from IDR 15,150,336 to IDR 2,628,572, with savings of IDR 12,521,764. Meanwhile, for *Baldor Tech*, total inventory costs fell from Rp. 22,725,505 to Rp. 3,219,330, resulting in savings of Rp. 19,506,175. Overall, the EOQ method successfully optimized inventory management by drastically reducing *holding* and *ordering* costs from a total of Rp. 94,050,050 to Rp. 15,683,075, resulting in savings of Rp. 78,366,930. This certainly helps to improve cost efficiency in the company.

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