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Improvement of Inventory Management to Reduce Cost of Buying New Inventory

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Abstract - **Natural gas is distributed through gas infrastructure from gas sources to consumers.Gas infrastructure must be maintained to minimize disruption of gas distribution. Inventory has important role to support gas infrastructure reliability especially if replacement of damaged materials is required. This study is conducted at natural gas distribution and transmission company. The purpose of this study is to evaluate the inventory management applied by the company to reduce the cost of purchasing new materials which results in high inventory level in 2020. This studyis using the fixed-time period model to determine safety stock level and order quantity should be placed. Pareto analysis is conducted to determine which materials contribute to 80% of total cost of buying new inventory in 2020. There are five materials that contribute the most and be analyzed further. Forecasting simulations are carried out to obtain demand forecasts based by using trend projection method.Trend projection forecasting method using quarterly data provides a lower error than trend projection forecasting method using monthly data. By implementing fixed-time period model, order quantity of each material can be reduced.**

Keywords - **Inventory Management, Safety Stock, Fixed-Time Period Model, Forecasting**

I. INTRODUCTION

Natural gas is one of energy source that used for cooking, heating, manufacturing, electricity generation and many so on. This energy contributes 23% shares of Indonesia's energy mix (theaseanpost.com, 2021). It shows that natural gas has important role to fulfil energy needs in Indonesia.With scattered natural gas resources in Indonesia, natural gas is distributed from gas producers to consumers through gas infrastructure. The infrastructure must be maintained to minimize disruption of gas distribution to consumers.Inventory has important role in maintenance activities especially if immediate replacement of damaged materials is required. This study is conducted in natural gas distribution and transmission company that controls more than 90% gas pipeline in Indonesia.

Inventory level of the company was increasing significantly in 2020. The company's inventory level rose 46% compared to the previous year. One of the reasons for this high inventory is the large amount of inventory purchased in 2020 without increasing in materials demand. Buying of new inventory is increasing significantly about more than 600% compared to previous year.

The study objective is to evaluate company's inventory management and provide solution to improve inventory management so that the company can reduce costof buying new inventory. Due to time limitation, this study is only conducted at one of three operation regions at the company that contributes 68% of new inventory cost. Moreover, only several materials that give high impact to the total cost will be analyzed further.

II. METHODOLGY

This research is conducted both qualitative and quantitative approach. After identifying business issue, the next step of this study is conducting interview and literature review related to inventory management. Interviewing the company's employee is done to identifythe root cause of the problem. Then, the literature review is done as a basis in proposing the right solution. The cost saving generated by the solution will be estimated to prove that the solution will give benefit to the company.

The existence of inventory will create costs. Therefore, inventory should be controlled. According to David Simchi-Levi (2000), the goal of inventory management is to have the correct inventory at the right place at the right time to minimize system costs while satisfying customer service requirements. Heizer & Render (2014) stated the objective of inventory management is to strike a balance between inventory investment and customer service.

According to Jacobs & Chase (2018), there are two systems in inventory control system which are single-period inventory system and multiperiod inventory system. This classification is based on how many purchasing decisions will be made. Single-period inventory system just needs one-time purchasing decision to cover demand for such a period. In the other hand, multiperiod inventory system will buy the material periodically and continuously to ensure the availability of material or inventory.

A. Fixed-Time Period Model

Fixed-time period model is one of multiperiod inventory system model. In this model, level is monitored

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within a certain period, for example every week, every month, or every year. The After the amount of inventory is known, order is placed so that the inventory level returns to the desired amount (target inventory). This system is also known as P-Model. According to Heizer & Render (2014), fixed-period model has several assumptions. First, the only relevant costs are the ordering and holding costs. Second, lead times are known and constant. Third, items are independent of one another. There are some advantages of fixed-time periods model as follows:

- Easy system administration as re-additions are possible in a fixed period
- Orders for multiple items from the same supplier can be combined in one purchase order

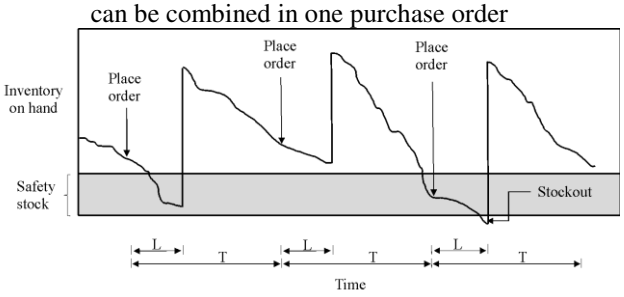

Fig. 1. Fixed-Time Period Model

- Inventory position can be known only when re-inspection occurs

Fixed-time period model will generate varied order quantity from period to period depending on demand during review time (*T*). The order will be placed when review time comes.

The order quantity should be placed at the time of review is:

$$q = \underline{d}(T + L) + z\sigma_{T+L} - I \quad (1)$$

Where:

q = quantity to be ordered
T = The number of days between reviews
L = Lead time in days
$\underline{d}$ = Forecast average daily demand
z = Number of standard deviations for specified service level
σ_{T+L} = Standard deviation of demand over review and lead time
I = Current inventory level (includes items on order)

To determine safety stock level that to be maintained is

$$\text{Safety stock} = z\ x\ \sigma_{T+L} \quad (2)$$

Where:

$$\sigma_{T+L} = \sqrt{(T + L)\sigma^2} \quad (3)$$

The value of z depends on how much service level want to be achieved. Service level reflects how many demands in can be fulfilled by inventory. The 100%-service level means not a single demand cannot be served by inventory or there is no stockout. Therefore, higher service level requires higher safety stock.

B. Forecasting

According to Heizer & Render (2014), forecasting is the art and science of predicting future events. Forecasting can use past data to be projected quantitatively using mathematical models or qualitatively according to the judgment of several people or experts. According to Jacobs and Chase (2018), forecasting is the basis of corporate planning and control.

There are three categories forecasting classified by the future time horizon that it covers, which are (Heizer & Render, 2014):

1. Short-range forecast: The time span of forecast is up to 1 year but is generally less than 3 months. It is used for planning purchasing, job scheduling, workforce levels, job assignments, and production levels.

TABLE 1
AGUIDE TO SELECTIING AN APPROPRIATE FORECASTIONG METHOD

Forecasting Method	Amount of Historical Data	Data Pattern	Forecast Horizon
Simple Moving Average	6 to 12 months; weekly data are often used	Stationary only	Short
Weighted moving average and simple exponential smoothing	5 to 10 observations needed to start	Stationary only	Short
Exponential Smoothing with Trend	5 to 10 observations needed to start	Stationary and trend	Short
Linier regression	10 to 20 observations	Stationary, trend, and seasonality	Short to medium
Trend and seasonal models	2 to 3 observations per season	Stationary, trend, and seasonality	Short to medium

(Source: Jacobs and Chase, 2018)

2. Medium-range forecast: The time span of forecast is from 3 months to 3 years. It is useful in sales planning, production planning and budgeting, cash budgeting, and others.
3. Long-range forecast: The time span of forecast is from 3 years or more. Long-range forecasts are used in planning for new products, capital expenditures, facility location or expansion, and research and development.

According to Heizer & Render (2014), there are two general approaches to forecasting which are quantitative approach and qualitative approach. Quantitative forecasts use a variety of mathematical models that rely on historical data and/or associative variables to forecast demand. Qualitative forecast is combining some factors such as the decision maker's intuition, emotions, personal experiences, and value system in forecast demand.

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One of quantitative approach is time-series models. There are four methods in time-series forecasting models which are (Heizer & Render, 2014):

1. Naive approach
2. Moving Averages and Moving Weighted Average
3. Exponential Smoothing
4. Trend Projection

III. RESULTS

A. *Pareto Analysis*

According to root cause analysis, there are two main causes that make inventory level increase significantly are high safety stock and inappropriate forecast method. The first step is to determine materials that give high impact to the problem by using pareto analysis. The materials that give 80% total cost will be analyzed further.

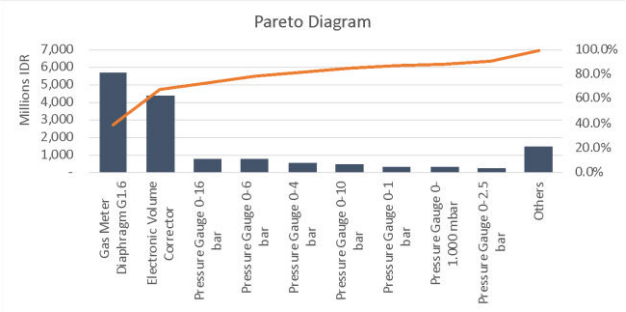

Fig. 2. Pareto Analysis Diagram

Based on pareto analysis, there are five materials that impact 80% of total new inventory cost as follows:

1. Gas Meter Diaphragm G1.6 (G1.6)
2. Electronic Volume Corrector (EVC)
3. Pressure Gauge 0-16 bar (PG16)
4. Pressure Gauge 0-6 bar (PG6)
5. Pressure Gauge 0-4 bar (PG4)

B. *Forecasting*

Theactualdemand of those five materials for 2018 to 2019isshown on chart below.

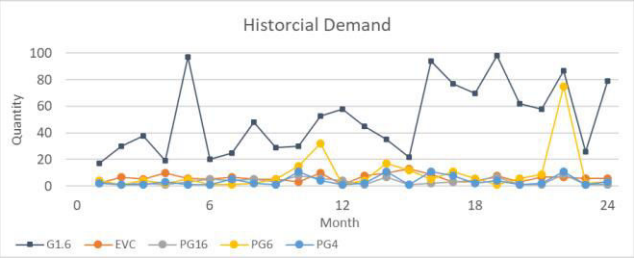

Fig. 3. Historical Demand of Five Materials

Based on company policy, same material is only bought once per year. Hence, medium-range forecasting should be done to predict the future demand for next year. According to literature review, only trend projection and regression analysis method can do medium forecast (3 months until 3 years). Due to data limitation to determine what possible independent variable that influence materials demand, the possible forecasting method used to predict future demand of material is trend projection.

This study is analyzing two trend projections based on the period which are monthly and quarterly. The forecasting result is shown on chart below.

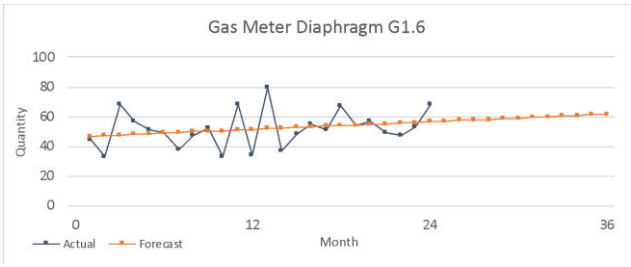

Fig. 4. Actual and Forecasting Demand of G1.6 - Monthly Trend Projection

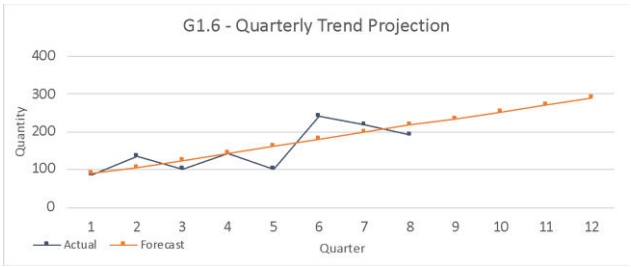

Fig. 5. Actual and Forecasting Demand of G1.6 –Quarterly Trend Projection

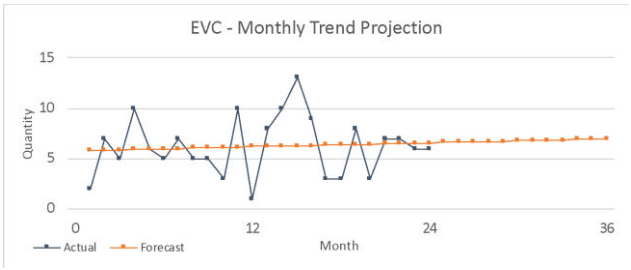

Fig. 6. Actual and Forecasting Demand of EVC –Monthly Trend Projection

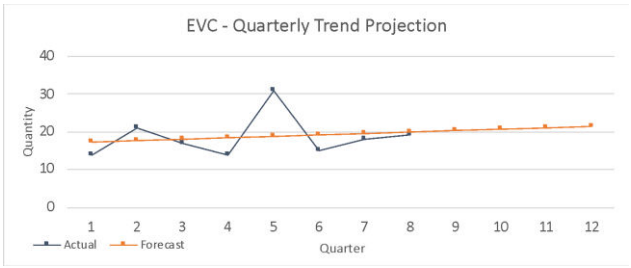

Fig. 7. Actual and Forecasting Demand of EVC –Quarterly Trend Projection

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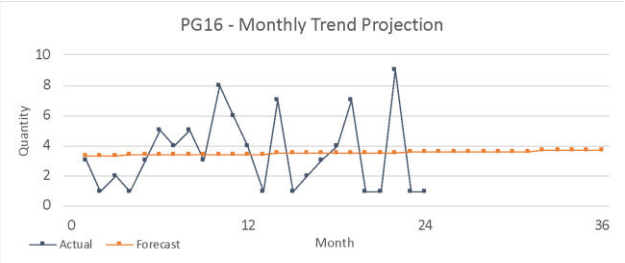

Fig. 8. Actual and Forecasting Demand of PG16 –Monthly Trend Projection

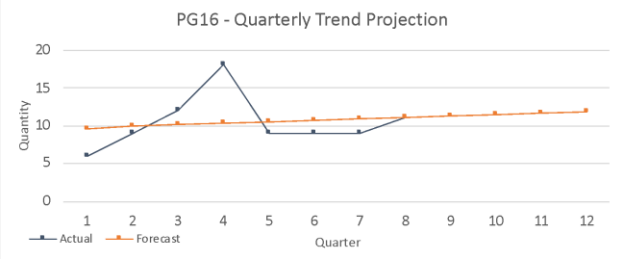

Fig. 9. Actual and Forecasting Demand of PG16 –Quarterly Trend Projection

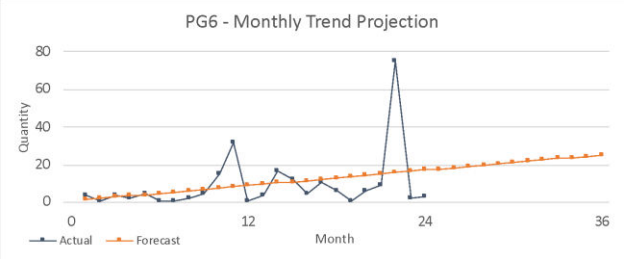

Fig. 10. Actual and Forecasting Demand of PG6 –Monthly Trend Projection

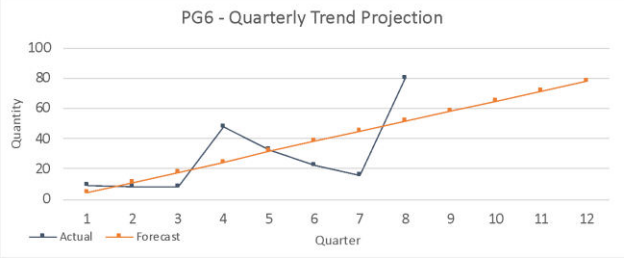

Fig. 11. Actual and Forecasting Demand of PG6 –Quarterly Trend Projection

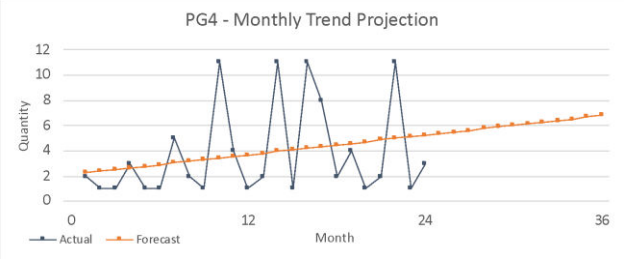

Fig. 12. Actual and Forecasting Demand of PG4 –Monthly Trend Projection

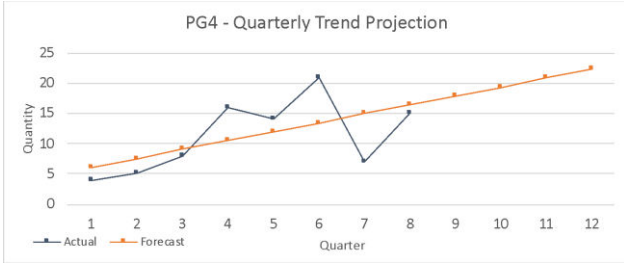

Fig. 13. Actual and Forecasting Demand of PG4 –Quarterly Trend Projection

C. Forecasting Error

The mean absolute percentage error (MAPE) is the best indicator to determine the most accurate forecasting method. Based on calculation, quarterly trend projection has the lowest MAPE value in all types of material. Therefore, quarter time bases and quarterly trend projection will be used in safety stock and order quantity calculation.

TABLE 2
ERRORCALCULATION

Material	Monthly Trend Projection		Quarterly Trend Projection	
	MAD	MAPE	MAD	MAPE
G1.6	17.23	44.42	27.79	**19.31**
EVC	2.29	64.15	3.87	**19.77**
PG16	2.03	106.31	2.41	**23.31**
PG6	8.52	230.88	14.5	**69.56**
PG4	2.82	130.12	3.76	**40.46**

D. Safety Stock and Order Quantity

After determining the best forecasting model can be applied, safety stock and order quantity each material can be calculated. Safety stock is calculated by using 98% service level and order quantity is calculated by using fixed-time period model. The calculation of safety stock and order quantity resultis shown on table below.

TABLE 3
SAFETYSTOCK AND ORDER QUANTITY CALCULATION

Material	Safety Stock (units)	Order Quantity (units)
G1.6	293	1,427
EVC	29	158
PG16	18	84
PG6	124	511
PG4	30	144

IV. DISCUSSION

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According to calculation results of order quantity, there is difference or gap between them and actual order quantity. There is a potential cost saving if fixed-time period model applied by the company. The estimation of potential cost saving is shown on table below.

TABLE 4
COST SAVING CALCULATION

Items	Order Quantity (Calculation)	Order Quantity (Actual)	Over Buying (Less Buying)	Unit Price (IDR)	Total (IDR)
G1.6	1,427	8,350	6,923	687,500	4,759,562,500
EVC	158	236	78	18,805,970	1,466,865,672
PG16	84	350	266	2,255,220	599,888,520
PG6	511	344	(167)	2,255,220	(376,621,740)
PG4	144	236	92	2,255,220	207,480,240
Total Saving					6,657,175,192

By implementing fixed-time period model the company can save IDR 6.6 billion or 44% total capital cost of buying new inventory with 98% service level. In similar other study, fixed-time period model can save 65%, 75% and 80% of inventory investment while providing 100%, 99.7% and 98% service levels, respectively (Mahfuz, Shahrul, & Islam, 2008).

Implementing appropriate inventory management system can generate lower order quantity. In this case, the company is implementing safety stock based on percentage of total installed material on gas infrastructure facility. It means that every increasing of gas infrastructure required more safety stock quantity that make safety stock requirement is so high. In the other hand, safety stock in inventory management based on deviation of historical demand. It will anticipate any fluctuation or changes on demand. Comparison between current safety stock and safety stock calculation is shown on table below.

TABLE 5
COMPARISON SAFETY STOCK BETWEEN CURRENT CONDITION AND CALCULATION

Materials	**Safety Stock (Calculation)**	**Safety Stock (Current)**	**Gap**
G1.6	293	3,501	3,208
EVC	29	120	91
PG16	18	18	0
PG6	124	67	(57)
PG4	30	69	39

V. CONCLUSION

According to calculation and business solution analysis on inventory management at the company, the author can conclude some points:

1. There are two causes that make high inventory level at the company which are high safety stock requirement and inappropriate forecasting method. Those causes generate high quantity to be ordered in 2020. The safety stock applied by the company is based on percentage of total installed material on gas infrastructure. Moreover, the company conducts forecasting based on historical data of material breakdown without considering the material can be repaired or not.
2. To solve the problem, the company should apply fixed-time period model inventory management. This model is appropriate for the company who is buying same material once per year. The safety stock calculation generates lower value than current safety stock policy. The best forecasting model can be applied by the company is quarterly trend projection because it gives lower MAPE value than monthly trend projection.
3. Based on order quantity calculation, the potential cost saving of buying new inventory obtained the company is IDR 6,657,175,192 if the company apply fixed-time period model inventory management system.

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