Jurnal Serambi Engineering JSE
Volume X, No.2, April 2025 Hal 13303 - 13313
p-ISSN : 2528-3561
e-ISSN : 2541-1934

Improving Inventory Control in the Electrical Sector Using Forecasting Models: A Comparative Study of ARIMA, Exponential Smoothing, Croston, and SBA

Elvi Armadani[1*], Daniel Jeffry[2], Muhammad As'adi[3], Yulizar Widiatama[4]

[1,3,4]Industrial Engineering Department, Universitas Pembangunan Nasional "Veteran" Jakarta, Jakarta
[2]Industrial Engineering Department, Institut Teknologi Sumatera, Lampung
*__Corresponding author:__ elviarmadani@upnvj.ac.id

Received: April 5, 2025 Approved: April 09, 2025

Abstract
PT. ABC Tarahan Sector is a State-Owned Enterprise that is engaged in services to distribute electricity to the general public. PT. ABC Tarahan Sector distributes about 80% of total electricity consumption in Lampung and 20% is distributed through ABC Palembang. Material planning is one of the most important factors to meet the production targets produced every year. The purpose of this study is to determine the method with the smallest error value based on the time series data available in the company. The data used in this study is the company's material demand data in 2018-2023. The level of accuracy in the forecasting value is determined by looking at the smallest absolute error value in each method. The forecasting results will then be measured based on the value of the service level, inventory level, and inventory cost budget. The existing condition of the company produces an error value of 7.32118, the amount of material is 17,195, the service level is 95.06%, and the warehouse cost is Rp. 36,012,143,757.00. The researcher forecasts using the Arima, Exponential Smoothing, Croston, and Syntetos Boylan Approximation methods. The results of the data analysis resulted in a decrease in the error value of 31.3%, a decrease in the amount of material by 22.38%, an increase in service levels to 95.33%, and a warehouse cost savings of Rp. 182,068,361.00.
Keywords: *forecast, ARIMA, exponential smoothing, croston, syntetos boyland approximation*

Abstrak
PT. ABC Sektor Tarahan merupakan Badan Usaha Milik Negara (BUMN) yang bergerak dalam bidang distribusi listrik kepada masyarakat umum. Perusahaan ini menyuplai sekitar 80% dari total konsumsi listrik di wilayah Lampung, sementara sisanya sebesar 20% didistribusikan melalui ABC Palembang. Perencanaan material menjadi salah satu faktor krusial dalam mencapai target produksi tahunan perusahaan. Penelitian ini bertujuan untuk mengidentifikasi metode peramalan dengan tingkat kesalahan terkecil berdasarkan data deret waktu dari tahun 2018 hingga 2023. Akurasi peramalan dievaluasi berdasarkan nilai kesalahan absolut terkecil dari setiap metode yang digunakan. Kinerja metode peramalan selanjutnya diukur berdasarkan nilai service level, level persediaan, dan anggaran biaya Gudang. Berdasarkan metode yang saat ini digunakan oleh perusahaan, nilai kesalahan yang tercatat adalah sebesar 7,32118, dengan jumlah material sebanyak 17.195 unit, tingkat layanan (service level) sebesar 95,06%, dan biaya gudang mencapai Rp 36.012.143.757,00. Penelitian ini menerapkan metode ARIMA, Exponential Smoothing, Croston, dan Syntetos–Boylan Approximation (SBA). Hasil analisis menunjukkan adanya penurunan nilai kesalahan peramalan sebesar 31,3%, penurunan jumlah material sebesar 22,38%, peningkatan tingkat layanan menjadi 95,33%, serta penghematan biaya gudang sebesar Rp 182.068.361,00.
Kata Kunci: *peramalan, ARIMA, exponential smoothing, croston, syntetos boyland approximation*

1. Introduction

The State Electricity Company PT. ABC is the largest electricity-producing service company in Indonesia. According to energy economist Fahmy Radhi, PT. ABC is the only electricity provider company in Indonesia. PT ABC has 56 main units, 373 implementing units, and 1,042 service units [1] which are spread throughout Indonesia, each with their respective functions and duties by the parent unit. PT. ABC Tarahan Sector divides the functions of its main unit based on the electric power system, including generating, transmission, and distribution units to provide electricity distribution services to the public. PT ABC Tarahan Sector has a function to distribute electrical energy for the Lampung area and has the main unit located in the Palembang area.

Jurnal Serambi Engineering
JSE
Volume X, No.2, April 2025 Hal 13303 - 13313
p-ISSN : 2528-3561
e-ISSN : 2541-1934

Based on existing data at PT. ABC, electricity consumption in Lampung area is 254.4 GWH per month and PT. ABC Tarahan Sector itself has a capacity of 2 X 100 GWH for a month and can meet the needs of 80% of the total demand in Lampung. The shortage of 20% of the Lampung province's community power is supplied through the main unit in Palembang so that it can meet all existing demands in the Lampung province.

According to the Assistant Manager of Communications at ABC UID (Unit Parent Distribution) Lampung, electric energy consumption has increased by 5.79 percent compared to 2020. The increase in electricity consumption occurred in the household tariff category up to 7.8%, the business tariff group by 2.5%, and social at 1.1% compared to April 2021. According to him, this increase was due to the many activities carried out at home such as teaching and learning activities that were still via virtual, causing higher consumption of electrical energy.

One of the problems that exist in inventory management is that most companies have not been able to apply optimal order and inventory sizes [2]. The most important asset for retail, service, or manufacturing company lies in its inventory. When there is an error in determining the amount of inventory needed, it will affect the total profit earned by the company.

The size of number of procurements planned by inventory management will have an impact on inventory costs. When the company has a low order value with a high number of orders, the ordering cost will be low and the holding cost will be high. When a company has a high order frequency value with a low number of orders, the ordering cost will be high and the storage cost will be low [3]. This can lead to stockout costs or costs incurred as a result of the company not having the required inventory which can cause the company's service level value to be below.

The main goal of the company is basically to reduce costs and get as much profit as possible within a certain period. PT ABC Tarahan Sector itself to improve the quality of its production is very concerned about the level of inventory in their company. When the material needed by the user is not available in the warehouse, it has a huge impact on the company.

Inventory problems can occur due to several factors, such as an excessive number of orders so that which can cause excessive inventory stock, and an insufficient number of orders so that which can cause inventory stock to become unavailable when the item is needed [3]. To be able to find the cause of the problem at the ABC company, the author makes a cause and effect diagram (fishbone) to better understand the existing problems.

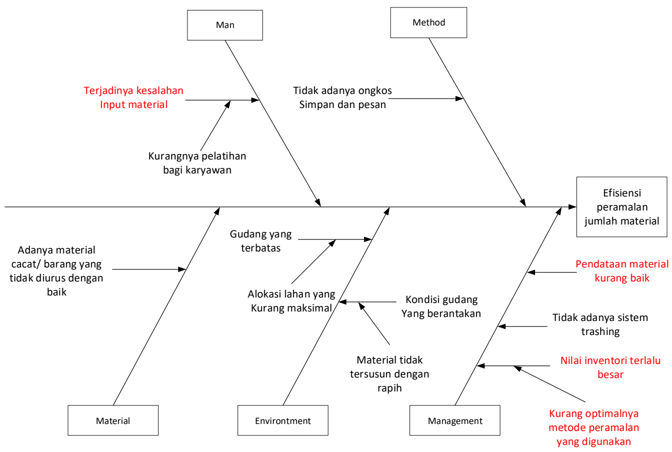

Figure 1. Fishbone Diagram

Figure 1 explains that the fishbone diagram explains what problems exist in the company's inventory system. These problems are measured based on human factors, methods, materials, environment, and management. The main problem in the fishbone diagram is determining the right policy in determining inventory policy. The company has been using the p and q methods to determine the total inventory and in using this method within a few years, the company often experiences deficiencies and advantages in each material. Based on this, the method suggested by the author is expected to be able to overcome the problems that exist in the company.

The purpose of this study was to determine the optimal amount of inventory for each material. The resulting forecasting results are expected to be able to overcome problems in warehouses that often occur

Jurnal Serambi Engineering JSE Volume X, No.2, April 2025 Hal 13303 - 13313 p-ISSN : 2528-3561 e-ISSN : 2541-1934

in overstock and out of stock. These results are also expected to be able to minimize the warehouse cost budget and increase the service level value for each material.

The pattern of demand for each spare part is different whether it is slow-moving, intermittent, erratic, or lumpy. Understanding this demand pattern is very important in managing spare parts inventory in the company. The uniqueness of the spare parts demand pattern is the irregular demand time. This irregularity causes the demand for spare parts to be very difficult to predict, so it requires an appropriate forecasting method to forecast the demand.

Many forecasting methods have been developed to date, ranging from classical statistical methods such as exponential smoothing, arithmetic to special methods such as Croston [4], Syntetos Boylan approximation (SBA) [5]. Based on these 4 forecasting methods, the Croston and SBA methods are forecasting methods used for the context of forecasting demand for spare parts. Managing spare parts inventory is quite different from managing raw materials for the production process [6]. Because of this, the author was compelled to conduct a research entitled "Material Inventory Policy Using Arima Method Approach, Exponential Smoothing, Croston, and Syntetos Boyland Approximation at PT. ABC Tarahan Sector".

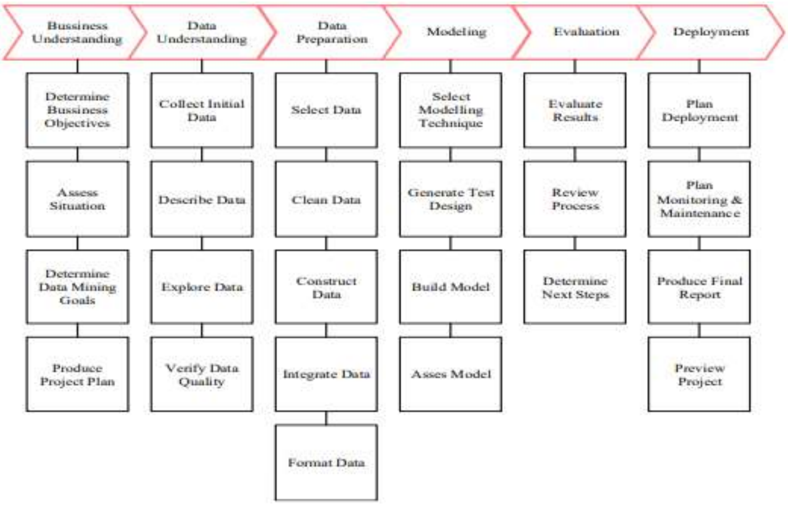

Figure 2. Analytics Process

Figure 2 explains the data analysis process is a thorough examination of the data. The process is carried out, among others, by performing data cleaning, transformation, and data modeling. The purpose of the data analysis process is to obtain information that can be useful for decision-making in the company.

2. Material and Methods

This study will compare the value of material forecasting using 4 methods, namely the Arima method, exponential smoothing, SBA, and Croston. The results of the forecast will be selected based on the smallest forecast error value.

Single Exponential Smoothing

Exponential smoothing is a method proposed in the late 1950s [10]. This method has then become one of the best forecasting methods. Forecasting results generated from this method use the average value of the previous historical data. This method can produce fast forecasting forecasts for a wider range of time where it is a big advantage and very important if it can be applied in the company. Exponential Smoothing method is an algorithm that produces an estimate of the point in the forecast. This model can produce forecasting results that are the same as the actual values but can also produce interval values in the predictions. This statistical model is basically a process that can produce stochastic data that can produce the entire distribution of estimates. Each model consists of a measurement equation that describes the observed data, and several equations of state that describe how the unobserved component or state (level, trend, seasonality) changes over time.

Table 1. Classification of Exponential Smoothing Method

Trend Component	Seasonal Component		
	N	A	M
	(None)	(Additive)	Multiplicative)
N (None)	(N, N)	(N, A)	(N, M)
An (Additive)	(A, N)	(A, A)	(A, M)
A_d (Additive damped)	(A_d, N)	(A_d, A)	(A_d, M)

Table 1 explains that the error assessment method can be calculated, among others, by Simple Exponential Smoothing with additive errors and Simple Exponential Smoothing with multiplicative errors. Forecasting points generated by this model can be identified when using the same parameter values but can also produce different prediction interval va to did distinguish between models with additive error and multiplication error, this method assigns a label with ETS (.,.,.,) filled with (Error, Trend, Seasonal).

Exponential Smoothing Holt-Winters additive

The additive seasonal model is used to calculate the value of the seasonal variance which has constant properties. This model is very suitable for making predictions on time series forecasts that have a high seasonal pattern that does not depend on the average value [15]. Seasonal assessment of the Holt-Winters method has additive properties but is rare. The equations used in the additive model are as follows.

a) Exponential Smoothing forecast

$$S_t = \alpha(X_t - l_{t-L}) + (1 - \alpha)(S_{t-1} + b_{t-1}) \quad (1)$$

b) Trend Exponential Smoothing

$$b_t = \gamma(S_t - s_{t-1}) + (1 - \gamma)b_{t-1} \quad (2)$$

c) Seasonal Exponential Smoothing

$$l_t = \beta(X_t - S_t) + (1 - \beta)l_{t-L} \quad (3)$$

d) Forecasting value in the next period

$$F_{t+m} = (S_t + b_t m)\ l_{t-L+m} \quad (4)$$

Where:
S_t = forecast value at t
X_t = t value
α = Smoothing constant on the original data (0 <α< 1)
γ = Smoothing constant in trend pattern (0 < < 1)
β = Smoothing constant on seasonal pattern (0 < < 1)
L = Seasonal length
b_t = Seasonal smoothing constant at time t
m = umber of periods to be forecast

ARIMA

Forecasting with the ARIMA method provides another approach to forecasting in time series. Exponential smoothing and ARIMA models are two approaches that are widely used for forecasting in time series and provide many approaches to solving these problems. The basic difference is that exponential smoothing is based on a description of trends and seasonality in the data, while Arima aims to describe autocorrelation in the data.

ARIMA known as (Autoregressive Integrated Moving Average) is one of the Box-Jenkins methods used to make forecasting predictions to analyze time series data. The ARIMA method is very good for forecasting in the short term, while for long-term forecasting the accuracy of forecasting is not good. The ARIMA model is included in the univariate model which makes this model very suitable if the observation values in time series data do not have a relationship with each other. Other advantages of using the ARIMA model include having a flexible nature by following data patterns, having a high forecasting accuracy value, not needing to do training tests so that it is faster to build models, and also the results issued are easy to interpret because the model coefficients are already known. , while the drawback of this ARIMA model is that it cannot capture unknown functional relationships in variables.

Classification in ARIMA consists of 3 groups including the Autoregressive (AR) model, the Moving Average (MA) model, and the Autoregressive Integrated Moving Average model. The ARIMA model itself is a combination of the Autoregressive (AR) model and the Moving Average (MA) model and with data that has been differencing as much as d.

Autoregressive Model (AR)

In the Autoregressive (AR) model, the current data value depends on the past data value [11]. In terms of autoregression, it indicates that the variable has regression properties. The autoregressive model of order p can be written as follows.

$$y_t = c + \theta_1 y_{t-1} + \theta_2 Y_{t-2} \ldots. + \theta_p Y_{t-p} + \varepsilon_t \quad (5)$$

Where:

y_t	= Predicted variable
$y_{t-1}, y_{t-2}, y_{t-p}$`	= lag on a dependent variable
C	= constant number
θ_p	= autoregressive parameter
ε_t	= residual value (error) at t time

The value of the equation on the order p or AR(P) is the value of observations in the past which is then entered to make forecasts in the future period. Changing the value of the _p parameter results in a different time series pattern. The variance of the error t value, wishill only change the series on the scale value and not the pattern

Autoregressive Integrated Moving Average (ARIMA)

When combining differencing with Autoregression and Moving Average models, we will get the non-seasonal ARIMA model. The overall model can be seen as follows.

$$y'_t = c + \theta_1 y'_{t-1} + \ldots. + \theta_p y'_{t-p} + \emptyset_1 e_{t-1} + \ldots + \theta_q \varepsilon_{t-q} + \varepsilon_t \quad (6)$$

The same stationary and invertibility conditions used for the Autoregressive and Moving Average models also apply to the ARIMA model. The special models that exist in ARIMA can be shown in the following.

White Noise	= ARIMA(0,0,0) without constant
Random Walk	= ARIMA(0,1,0) without constant
Random Walk with drift	= ARIMA(0,1,0) without constant
Autoregression	= ARIMA(p,0,0)
Moving Average	= ARIMA(0,0,qfd)

Croston

Croston is a forecasting method that first appeared in 1972 which was developed by J.D. Croston. Croston proposed a method that can handle an intermittent request. This method not only focuses on the size of a request (demand size), but also the time interval between requests (inter-demand interval) which is included in the calculation to make predictions [16]. This is the main reason that this model is very suitable for forecasting intermittent demand.

The Croston method will divide the forecasting data into two parts, including the historical demand data z_t and the demand interarrival time data p_t. When doing the analysis in period t, and when there is no demand in that period, the value of the estimated demand and the time interval does not change. When a request occurs, x_t> 0 so that the forecast value can be updated.

$$z_t = \begin{cases} z_{t-1}, if\ x_t = 0 \\ \alpha . x_t + (1-\alpha)\widehat{z_t}, if\ x_t > 0 \end{cases} \quad (7)$$

$$q_t = \begin{cases} q_{t-1} + 1, if\ x_t = 0 \\ 1, if\ x_t > 0 \end{cases} \quad (8)$$

$$p_t = \begin{cases} p_{t-1}, if\ x_t = 0 \\ \alpha . q_{t-1} + (1 - \alpha). p_{t-1}, if\ x_t > 0 \end{cases} \quad (9)$$

Where:
x_t = request data in period t
z_t= average demand prediction in period t (demand is positive)
p_t= average interval of non-zero requests in period t
α = smoothing constant between one and zero

Syntetos Boyland Approximation

SBA (Syntetos Boyland Approximation) method is an updated method of the Croston method [17]. Syntetos and Boyland proved that the Croston method produces biased calculations. The SBA method is made to improve the calculation of the bias by providing a suggestion to reduce the calculation of the forecast value in the Croston method with a factor (1 - α). The formula for the Syntetos and Boylan method proposes as follows.

$$F_{t+1} = (1 - \frac{\alpha}{2}) . \frac{z_t}{p_t} \quad (10)$$

Accuracy Forecasting

The method determined to calculate the forecast accuracy value can be determined based on the error value of each resulting method and the error value is obtained based on the difference between the actual value and the forecast value. The smaller the resulting error value, the better the forecasting method. the difference between the observed value and the forecast value is often referred to as the residual value. To calculate the error value of the forecast can use the following formula.

1) Forecast Error
$$e_i = X_i - F_i \quad (11)$$
2) *Mean error*
$$ME = \frac{1}{n} \sum_{i=1}^{n} e_i \quad (12)$$
3) *Mean absolute error*
$$MAE = \frac{1}{n} \sum_{i=1}^{n} |e_i| \quad (13)$$
4) *Percentage error*
$$PE_t = \frac{X_t + F_t}{F_t}\ X\ 100\% \quad (14)$$

3. Results and Discussion

Forecast error

This chapter consists of an analysis of the calculation of error values, inventory level values, service levels and warehouse costs based on the existing policy method, analysis of the Arima method, Exponential Smoothing, Croston, and Syntetos Boyland Approximation.

The calculation of the error value is obtained based on the difference between the results of the material forecast compared to the actual demand value. The forecast uses historical company data consisting of 2018-2023 as training data and 2019 as test data. The results of forecasting material demand are obtained using the Arima method, Exponential Smoothing, Croston, Syntetos Boyland Approximation, and the existing policy, then the error value data obtained are as follows.

Table 2. Forecast Error

Model	Mean error
Arima	10,552872
Croston	NaN
ETS	22,506451
SBA	NaN
Existing	7,321188

Based on **Table 2**, it can be seen the error value generated in each method. Forecasting values generated using the Arima method, the resulting error value is 10.552872 and with the Exponential Smoothing method, the resulting error value is 22.506451, while the Croston and Syntetos Boyland Approximation method, the resulting error value is NaN (Not a Numbers).

The error value arises because there is material that cannot be predicted using the two methods, the Croston and SBA methods can predict if there is at least a 2-year amount of material demand in the data. The error value resulting from forecasting the existing method has a smaller value, which is 7.321188. This indicates that the method used by the company is good enough to be implemented in forecasting the amount of material.

The next stage is that researchers want to develop by combining the forecasting results of the 4 selected methods and the company's existing methods. The five methods will be selected based on the smallest error value generated when forecasting. The existing method used by the company is the p and q method. The method is then improvised on several calculations such as when looking for the safety stock value.

Table 3. Comparison of Error Values for Optimum and Existing Methods

Model	Mean error
5 method combine	5.03
Existing method	7.321188

Table 3 can be seen that by combining the 5 established methods, it can minimize the error value generated by the existing method. The error value generated by a combination of 5 methods produces an average of 5.03, while the existing method produces an error value of 7.321188.

Table 4. Error Value of Each Material

No	**Material**	**Model**	**RMSE**
1	ACTUATOR ACC;POSITIONER SIPART PS2	ETS	4,2
2	ACTUATOR;AUM;SA075AM011;GS1003	Ekxisting	0
3	ACTUATOR;AUM;SA075AM011GF1003	Arima	0
…	…	…	…
1861	CHEM;HYDRAVER 2;H-179032	SBA	0,5
	Mean error		5,03

Table 4 describes the proportion of methods used to forecast each material. The method was chosen based on the smallest error value from the resulting forecasting. Based on the table, we can also see that the ARIMA method was used to predict 61 materials, Exponential Smoothing 50 materials, Croston 16 materials, SBA 12 materials, and the existing method as many as 1722 materials.

$$error\ accuracy = \left(\frac{predicted - actual}{actual}\right) X\ 100\%$$

$$error = \left(\frac{5.03 - 7.321188}{7.321188}\right) X\ 100\%$$

$$error\ accuracy = -31{,}3\%$$

The calculation of the percentage error rate is used to determine the magnitude of the decrease in the resulting error value. In the combination of these 5 methods, there is a percentage decrease in the error value of 31.3%. This is because the values of some materials that produce error values are too high compared to the four proposed methods.

Inventory level

Determining the value of the inventory level will affect the allocation of material storage and also the costs that will be invested in purchasing materials. The less the amount of material ordered, the smaller the cost allocation used. The company targets that the amount of material ordered can be as optimal as possible in order to reduce the value of waste in the warehouse. The number of orders and the amount of material can be seen in the following table.

Jurnal Serambi Engineering JSE
Volume X, No.2, April 2025 Hal 13303 - 13313
p-ISSN : 2528-3561
e-ISSN : 2541-1934

Table 5. Optimum Material Quantity

Model	Material
5 method combine	13.346
Existing method	17.195

Table 5 produces data regarding the comparison of the total amount of material. The combination of 5 methods predicts the amount of material used as many as 13,346 materials. The company's existing method predicts the total material needed by the company is 17,195 materials. Based on the table, it is known that there has been a material decrease of 3,849 materials. These results will be tested on how optimal the method is to improve the company's inventory performance based on the service level value.

$$precentage\ decrease = \left(\frac{predicted - actual}{actual}\right) X\ 100\%$$
$$precentage\ decrease = \left(\frac{13.346 - 17.195}{17.195}\right) X\ 100\%$$
$$precentage\ decrease = -22{,}4\%$$

The calculation is carried out to determine the magnitude of the decrease in the total material used by the company. In the combination of these 5 methods, there is a percentage decrease in the number of material orders by 22.4%. It also shows that the company can save the amount of material ordered by 3,849 units.

Service level

Assessment at the service level is measured to determine how effective the forecasting method used to predict the amount of material demand is. The higher the service level value obtained, the better for the company. The calculation of the service level and the results of the assessment will be shown in the following table.

Table 6. Optimum Service Level Value

Model	*Service Level*	*Service Level* > 100%
5 method combine	95,33%	172,4%
Existing model	95,06%	246,9%

Table 6 describes the value of the service level on a combination of 5 methods and the company's existing model. in the table it can be seen that the combination of 5 methods can produce a service level value of 95.33%. Meanwhile, the company's existing model produces a smaller value of 95.06%. The table also shows the average material that is overstocked through the service level value which has a value of more than 100%. The combination of 5 methods has a smaller average of 172.4% while the company's existing model has a larger overstock value of 246.9%.

Table 7. Service Level Value of Each Material

No	Material	*Service level*
1.	ACTUATOR ACC;POSITIONER SIPART PS2	43%
2.	ACTUATOR;AUM;SA075AM011;GS1003	100%
3.	ACTUATOR;CCI;MFWCV;30202002SOFT	100%
…	…	…
1861	CHEM;HYDRAVER 2;H-179032	100%
	Average service level	95,3%

Table 7 displays data for each material using a combination of 5 methods. In this table, we can find out the service level value obtained for each material and also what materials have overstock.

Jurnal Serambi Engineering JSE Volume X, No.2, April 2025 Hal 13303 - 13313 p-ISSN : 2528-3561 e-ISSN : 2541-1934

Table 8. Service Level Value Optimal Method (Overstock)

No	Material	Service level
1.	CHEM;CAUSTIC SODA;LIQUID 48%	776%
2.	BEARING;CYL ROLLER;NU 413	200%
3.	INVERTER;480VAC;460VAC;3P;2.2K	700%
…	…	…
53	CHEM;AMMONIA HYDROXIDE SOLUTION;25%	103%
	Average *service level*	172,4%

Table 8 shows the service level values that are overstocked and it can be seen that there are 53 materials that are overstocked in the combination of these 5 methods. Overstock occurs when the predicted material exceeds the required amount of material. The forecasted material exceeds the estimated amount, will be able to cause waste in warehouse costs and based on the table, we can analyze which materials experience the highest overstock to the average percentage obtained for each material.

Table 9. Service Level Value Existing Method (Overstock)

No	Material	Service level
1.	Chem;caustic soda;liquid 48%	776%
2.	Univ acc;bolt&nut cs m12x50mm	733%
3.	Conveyor acc;belt 900wx3px10mmx17m	200%
…	…	…
59	Boiler acc;furnace fluidizing air nozzle	110%
	Rata-rata *service level*	246,9%

Table 9 shows the overstocked material in the existing model, where the average value generated is 246.9%. This proves that the combination of these 5 methods can minimize stockpiling of goods in warehouses which is a problem within the company.

Inventory Cost

Determination of warehouse costs is obtained by multiplying the number of forecasted materials with the price of each material obtained based on data from suppliers. These results will be tested to determine whether the proposed method can minimize the amount of budget allocated to warehousing.

Table 10. Comparison of Optimum and Existing Method Budget

Model	Total Cost	
Combines 5 Method	Rp	35,830,075,396.00
Model Existing	Rp	36,012,143,757.00

Based on **Table 10**, it can be seen that there is a decrease in the total budget in the combination of the 5 methods. It is known that the total budget generated by using a combination of 5 methods is Rp. 35,830,075,396.00 where the budget is smaller than the total budget generated using the existing method of Rp. 36,012,143,757.00. the total savings that can be made by a combination of 5 methods is Rp. 182,068,361.00.

4. Conclusion

The combination of 5 methods is used to produce a more accurate forecast value for the company. a combination of 5 methods can minimize the error value of 31.3%. The existing method produces an inventory level value of 17,195 material, the service level value is 95.06%, and the inventory cost is Rp.36,012,143,757.00. The combination of 5 methods can produce a value of inventory level of 13,346 materials, service level value of 95.33%, and warehouse costs of Rp. 35,830.075.396.00. It is known that the combination of the 5 methods can reduce the value of inventory level by 22.4%, increase the value of service level by 0.27%, and decrease warehouse costs by 0.51%.

Strategic preparation made up of five aspects such as legal foundation, institutional, funding, community participation, and operational technique has the ability to significantly reduce household waste. Therefore, it is recommended that they are applied simultaneously due to their interrelation. This is because if only a few aspects are applied, there will only be a very low chance of achieving significant waste reduction. Moreover, none of them enjoys special priority, since the implementation is often adjusted by the conditions of municipal household waste. However, it is important for the city to provide waste infrastructure and facilities prior to implementing these five aspects, especially in order to achieve the target of 30% waste reduction by 2025. Notably, the biggest waste reduction was observed to be in the TPS3R and the 3R Community Center.

5. References

[1] S. P. P. (Persero), "Laporan Statistik," Juni 2020. [Online]. Available: https://web.pln.co.id/stakeholder/laporan-statistik.

[2] S. Assauri, Manajemen Operasi Produksi, Jakarta: PT. Raja Grafido Persada, 2016.

[3] S. Bahagia, Sistem Inventory, Bandung: ITB, 2006.

[4] D. Croston, "Forecasting and Stock Control for Intermittent Demands," *Operational Research Quarterly,* pp. 289-303, 1972.

[5] E. B. &. D. C. A.A. Syntetos, "On The Categorization of Demand Patterns," *On the Categorization of Demand Patterns,* 2005.

[6] A. H. Nasution, Perencanaan dan Pengendalian Produksi, Yogyakarta: Graha Ilmu, 2008.

[7] G. James, An Introduction to Statistical Learning, Springer Text in Statistics, 2021.

[8] W. Tukey, "The Future of Data Analysis," Ann. Math. Statist, pp. 1-67, 1962.

[9] N. S. F. S. R.T. Willemain, "A New Approach to Forecasting Intermittent Demand for Service Parts Inventories," International Journal of Forecasting, pp. 375-387, 2004.

[10] E. Holt, Forecasting seasonals and trends by exponentially weighted averages, Pittsburgh USA: Carnegie Institute of Technology, 1957.

[11] J. R. Hyndman, Forecasting: principles and practice, 3rd edition, Melbourne, Australia: OTexts, 2021.

[12] S. Gardner, "Exponential smoothing: The state of the art.," Journal of Forecasting, pp. 1-28, 1985.

[13] W. Taylor, "Exponential smoothing with a damped multiplicative trend," International Journal of Forecasting, pp. 715-725, 2003.

[14] J. Hyndman, "Forecasting with exponential smoothing," Management Science, pp. 311-315, 2008.

[15] Makridakis, Metode dan Aplikasi Peramalan, Jakarta: Erlangga, 1999.

[16] E. L. &. A. Segerstedt, "Inventory Control with a Modified Croston Procedure and Erlang Distribution," International Journal of Production Economics, pp. 361-367, 2004.

[17] E. J. Boyland, "“The accuracy of a Modified Croston Procedure"," International Journal of Production Economics, pp. 511-517, 2007.

[18] Sugiyono, Memahami Penelitian Kualitatif, Bandung: ALFABETA , 2012.

[19] S. K. Nayak, "Enhanced innate immune parameters in Labeo rohita," Fish and Shellfish Im munology, pp. 168 - 172, 2008.

[20] S. Assauri, Manajemen Operasi Produksi, Jakarta: PT. Raja Grafido Persada, 2016.

[21] T. Bantacut, "Penerapan Logistik 4.0 dalam Manajemen Rantai Pasok Beras BULOG," Jurnal Pangan, pp. 141-154, 2018.

[22] V. Gasperz, Production Planning and Inventory Control, Jakarta: Gramedia Pustaka Utama, 2004.

[23] a. e. Fogarty, Production and Inventory Management, South-Western: Publishing Company, 1992.

[24] E. Herjanto, Manajemen Produksi dan Operasi, Jakarta: PT. Grasindo, 2003.

[25] C. Narbuko, Metodologi Penelitian, Jakarta: Bumi Aksara, 2008.

[26] H. Kusuma, Manajemen Produksi, Perencanaan dan Pengendalian Produksi. Edisi 4, Yogyakarta: Andi, 2009.

[27] E. L. Koher, Produksi dan Bahan Baku, Jakarta: Gramedia, 2006.

[28] Jogiyanto, Sistem Teknologi Informasi, Andi Offset, 2008.

[29] A. H. Nasution, Teknik dan Metode Peramalan, Surabaya: Guna Widya, 2003.

[30] N. I. Pujawan, Supply Chain Management, Surabaya: Guna Widya, 2005.

[31] PLN, "Panduan Pengisian Material," PT. PLN, Lampung Selatan, 2018.

[32] PLN, "Laporan Manajemen Material," PT. PLN, Lampung Selatan, 2020.

[33] A. Ristono, Manajemen Persediaan, Yogyakarta: Graha Ilmu, 2013.

[34] F. Rangkuti, Manajemen Persediaan: Aplikasi di Bidang Bisnis, Jakarta: PT. Raja Grafindo Persada, 2007.

[35] A. Sugiono, Manajemen Keuangan untuk Praktisi Keuangan, Jakarta: Grasindo, 2010.

[36] A. Sofjan, Manajemen Produksi dan Operasi. Edisi 4, Jakarta: Lembaga Penerbit Fakultas Ekonomi Indonesia, 2008.

[37] Sugiyono, Metode Penelitian Kuantatif Kualitatif, Bandung: Alfabeta, 2012.

[38] A. W. Tunggal, Manajemen Logistik dan Supply, Jakarta: Harvarindo, 2009.

[39] T. d. P. B. Tanthatemee, "‘Fuzzy Inventory Control System for Uncertain Demand and Supply," IMECS 2012, p. Vol 2, 2012.

[40] L. Syamsuddin, Manajemen Keuangan Perusahaan, Jakarta: Grafindo Persada, 2009.