Fuel Consumption Forecasting in a Mining Industry Using Moving Average Forecasting Method and Single Exponential Smoothing Method in PT. Pertamina Geothermal Energy

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Abstract
Geothermal energy is a renewable energy source because of the heat continuously produced inside of the earth, the use of geothermal resources are utilized primarily for the use of electric power generation. PT. Pertamina Geothermal Energy (PGE) now manages 5 areas for extracting geothermal energy around the country. In carrying out energy extraction in those five areas, PT. Pertamina Geothermal Energy (PGE) requires a fuel supply. Fuel receipts and fuel consumption that occur in those five areas at PT. Pertamina Geothermal Energy (PGE) often occurs in situations where supply acceptance and consumption are different. Therefore, a forecasting method is needed that is in accordance with the characteristics of the PT. Pertamina Geothermal Energy (PGE) company data type in order to get the most accurate forecast results for supply planning in the next period. So, by analyzing the type of historical data of the company, we will do a forecast with 2 methods; single moving average and single exponential smoothing. By comparing the forecast results from both methods, it will be analyzed which method is more suitable and accurate for the type and trend of PT. Pertamina Geothermal Energy (PGE) company data.

Keywords
Forecasting, Single Moving Average, Single Exponential Smoothing.

1. Introduction
Geothermal energy is a renewable energy source because of the heat continuously produced inside of the earth. The use of geothermal resources are utilized primarily for the use of electric power generation, whereas the other uses are utilized mostly for space heating and other direct uses. In the last year, the demand for geothermal energy in Indonesia has increased by about 10% every year. It happens because there are many communities that start to use electric networks in their daily life. PT. Pertamina Geothermal Energy (PGE) started to survey and exploit more than 70 areas in Indonesia that can be utilized for producing electric energy since 1974. And right now, the company is managing 5 areas for extracting geothermal energy around the country.

The 5 areas where Pertamina geothermal energy is used to extract geothermal energy are Karaha, Lumut Balai, Lahendong, Ulubelu, and Kamojang. In carrying out energy extraction in those five areas, PT. Pertamina Geothermal Energy (PGE) requires a fuel supply. The fuel supply needed by PT. Pertamina Geothermal Energy (PGE) consists of two types, namely diesel, and petalite. Fuel receipts and fuel consumption that occur in those five areas at PT. Pertamina Geothermal Energy (PGE) often occurs in situations where supply acceptance is lower than consumption or situations where supply acceptance is higher than actual consumption.

This situation can have a negative impact on the company which can cause revenue losses and excess costs. To overcome this situation, PT. Pertamina Geothermal Energy (PGE) requires solid planning regarding the fuel needs that will be needed in the next period. Of course, the required supply planning must have high accuracy in order to get accurate results. Therefore, a forecasting method is needed that is in accordance with the characteristics of the PT. Pertamina Geothermal Energy (PGE) company data type in order to get the most accurate forecast results for supply planning in the next period. There are various forecast methods where each forecast method refers and is more accurate to a certain type of data. Referring to this, historical data regarding fuel consumption from PT. Pertamina Geothermal Energy (PGE) is important. Therefore, by analyzing the type of historical data of the company, we will do a forecast with 2 methods; single moving average and single exponential smoothing. By comparing the forecast results from both methods, it will be analyzed which method is more suitable and accurate for the type and trend of PT. Pertamina Geothermal Energy (PGE) company data. So that through this analysis, PT. Pertamina Geothermal Energy (PGE) fuel consumption in the coming period can be forecasted accurately and solidly with the appropriate forecasting method so that there will be no overstock or out-of-stock.

1.1 Objectives

The objective of this paper is to help PT. Pertamina Geothermal Energy (PGE) chooses the correct forecasting method that can accurately predict the needed fuel consumption for the company. This paper aims to provide the needed information using two different methods; Single Moving Average and Exponential Smoothing. These two methods will use the actual data from the company in 2020 - 2021.

2. Literature Review

In the present associations, which are subject to abrupt changes and where all requirements of the business sector need accurate and practical reading into the future, the forecasts are becoming exceptionally crucial since they are the indication of survival and the language of business (Bozarth et al, 2016). Forecasting refers to the activity of predicting future outcomes by taking present and past events into consideration. Forecasting is a decision-making tool that assists businesses to cope with the impact of the future's uncertainty by analyzing historical data and trends. The objective is to foresee the future of the production quantity and inventory management in order to balance the conflict of not wanting to hold too much stock and the desire to make items or goods always available when required (SuwanAchariya et al, 2012). Forecasting is a decision-making tool used by many businesses to help in budgeting, planning, and estimating future growth. Therefore, companies should apply forecasts to have a clear vision for the future (Bashnaini et al. 2018).

Forecasting means predicting the future based on past, and present data and most commonly by analysis of trends. The more data used for forecasting the more accurate the results. However, there is evidence from the case that the reason lies in environmental uncertainty and volatility and not in internal factors within the company's control (Rieg 2009). Forecasting by a single moving average method based on time series is generated by a constant process subject to random error. The mean is a useful statistic and can be used as a forecast for the next period. Moving averaging methods are suitable for stationary time series data where the series is in equilibrium around a constant value (the underlying mean) with a constant variance over time (Gudagunti and Ali 2018). The smoothing exponential method is a weighted moving average forecasting methodology that uses an exponential function to weight the data. Smoothing exponential is an advanced weighted moving average forecasting approach that is yet simple to apply. This method requires relatively little data from the past.

In 2020 Agustian made a study to compare the simple moving average method with the exponential smoothing method to estimate future seaweed prices, and the results show that the moving average method is the best option. A similar study was conducted, in a study to design a forecasting system for a new car, Laksana contrasted the single moving average with the single exponential smoothing approach in 2017. According to the findings, the single moving average method produces the lowest error value.

3. Methods

Several steps of research methodologies will be conducted in order to make a better inventory plan to make the cost of production in PT. Pertamina Geothermal Energy (PGE) lower. Sequentially, all of the steps are summarized as follows:

1. Introduction and Literature Study
   The literature study that will be carried out is related to this research topic. This study will focus on defining quantitative forecasting, especially the Single Moving Average and single exponential smoothing method.
2. Data Collecting
   The data which will be used in this study is the historical data of fuel consumption and fuel supply in PT. Pertamina Geothermal Energy (PGE) for operational activities in the four extraction areas. The time period that will be used in this research is the quarterly period from the year 2020 until 2021.
3. Making a New Forecast of the Fuel
   The next step of the research is to forecast the fuel requirement for the next year with a single moving average forecasting method and a single exponential smoothing forecasting method.
4. Comparison of Single Moving Average and Single Exponential Smoothing
   After we get the forecast with these two methods of the forecast, we compare these two methods to what method is more accurate.
   The formula that is applied in the SMA method is
   $$SMA = (X_{t-1} + X_{t-2} + \dots + X_{t-n}) / n$$
   With
   X_{t-1} = Actual occurrence in the past period for up to n periods
   n = Numbers of the period to be averaged $X_{t-1} + X_{t-2} + \dots + X_{t-n}$

   And also the formula for SES method is
   $$Ft+1 = \alpha Xt + (1-\alpha) Ft-1$$
   With

   Ft+1 = Forecast for period t+1
   Xt = Real value of period t
   α = Weight indicating smoothing constant (0 < <1)
   Ft-1 = Forecast for period t-1
5. Result Analysis
   After comparing the accuracy of these two methods, we choose what method is more accurate so we can use the method for the upcoming forecast.

4. Data Collection

The data presented below is the usage of fuel that Pertamina used every quarter from 2020 to 2021 in liters. The data is collected from the report that PT. Pertamina Geothermal Energy (PGE) is used only for normal consumption and doesn't include the fuel that is needed for drilling requirements. This historical data will be used as the base information to forecast the production target in the first quarter of 2022.

Table 1. PT Pertamina Geothermal Energy Fuel Usage Data

Month	Diesel Usage in Karaha (liter)	Diesel Usage in Lumut Balai (liter)	Diesel Usage in Lumut Lahendong (liter)	Diesel Usage in Kamojang (liter)	Pertalite Usage in Kamojang (liter)
First Quarter 2020	25515	63619	24174	39546	3895
Second Quarter 2020	29329	67110	13305	29561	3708

Third Quarter 2020	25032	76837	17152	34669	4913
Fourth Quarter 2020	27138	67770	22005	40494	4863
First Quarter 2021	14381	22690	21145	26636	3334
Second Quarter 2021	15999	33895	18051	20751	3382
Third Quarter 2021	16994	40051	24495	46971	3494
Fourth Quarter 2021	37871	24107	49247	64190	3545

5. Results and Discussion

5.1 Numerical Results

We have forecast the total fuel consumption of the PT. Pertamina Geothermal Energy (PGE) for operational activities that will be needed in the first quarter of 2022 in the four geothermal energy extraction areas using single moving average and single exponential smoothing methods by analyzing historical data in the first quarter of 2020 to the last quarter of 2021. The results of the forecast using the single moving average method that we get for the use of fuel in the first quarter of 2022 in Karaha, Lumut Balai, Lahendong, Kamojang (Diesel), and Kamojang (Pertalite) are 23,621, 32,684, 30,598, 43,971, 3,474 liters respectively. And also the results of the forecast using the single exponential smoothing method that we get for the use of fuel in the first quarter of 2022 in Karaha, Lumut Balai, Lahendong, Kamojang (Diesel), Kamojang (Pertalite) are 23,649, 27,444, 63,956, 64,226, 3,803 liters respectively.

a. Karaha

Table 2. Karaha Forecast Result

Consumption Projection	Single Moving Average (Liters)	Single Exponential Smoothing (Liters)
Forecast	23.621	23.649
Upper Limit	46.716	40.140
Lower Limit	526.404	7.157

b. Lumut Balai

Table 3. Lumut Balai Forecast Result

Consumption Projection	Single Moving Average (Liters)	Single Exponential Smoothing (Liters)
Forecast	32.684	27.444
Upper Limit	-14.033	54.798

Lower Limit	79.402	90

c. Lahendong

Table 4. Lahendong Forecast Result

Consumption Projection	Single Moving Average (Liters)	Single Exponential Smoothing (Liters)
Forecast	30.598	63.956
Upper Limit	55.906	78.830
Lower Limit	5.289	49.082

d. Kamojang (Diesel)

Table 5. Kamojang (Diesel) Forecast Result

Consumption Projection	Single Moving Average (Liters)	Single Exponential Smoothing (Liters)
Forecast	43.971	64.226
Upper Limit	79.696	83.058
Lower Limit	8.245	45.394

e. Kamojang (Pertalite)

Table 6. Kamojang (Pertalite) Forecast Result

Consumption Projection	Single Moving Average (Liters)	Single Exponential Smoothing (Liters)
Forecast	3.474	3.803
Upper Limit	4.980	5.093
Lower Limit	1.967	2.512

5.2 Graphical Results

The methods which are used to process the data are Single Moving Average, and Single Exponential Smoothing method. The purpose of this process is to look for the most precise forecasting method. A better forecasting method will be used to forecast the diesel consumption of PT. Pertamina Geothermal Energy (PGE) company in 2022. The graphical results for both methods are presented below.

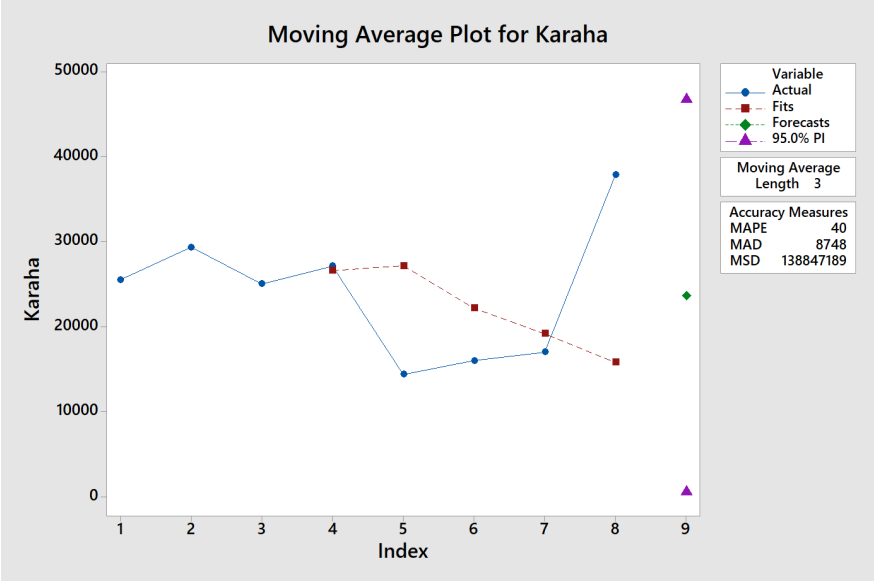

Figure 1. Single Moving Average for Karaha

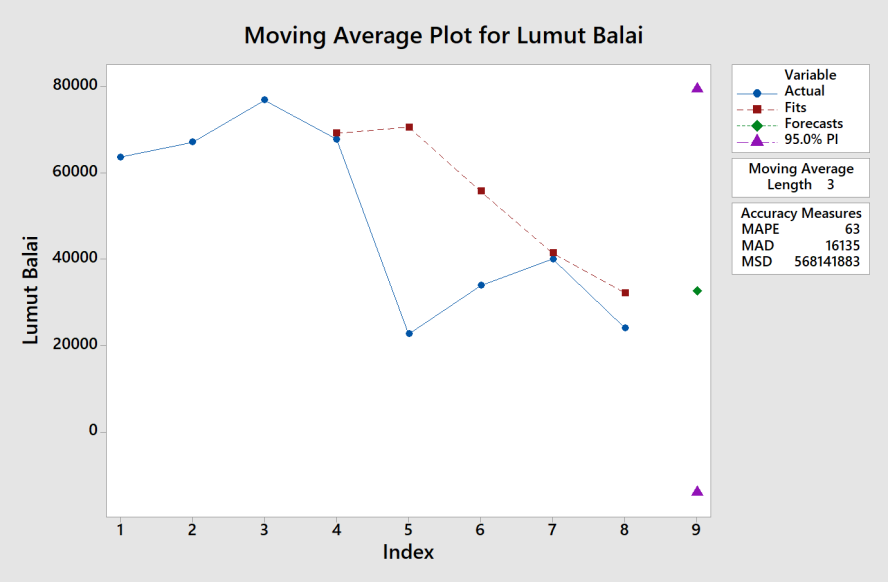

Figure 2. Single Moving Average for Lumut Balai

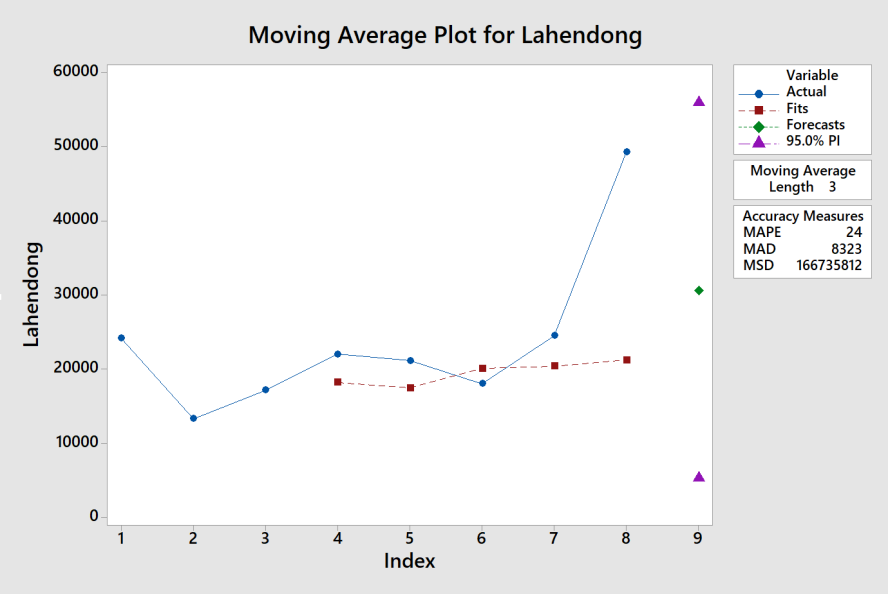

Figure 3. Single Moving Average for Lahendong

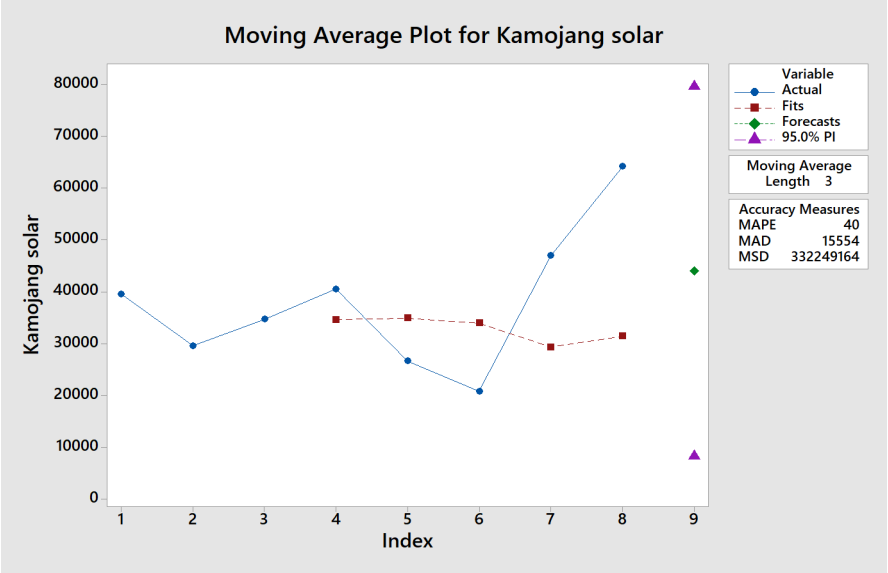

Figure 4. Single Moving Average for Kamojang (Diesel)

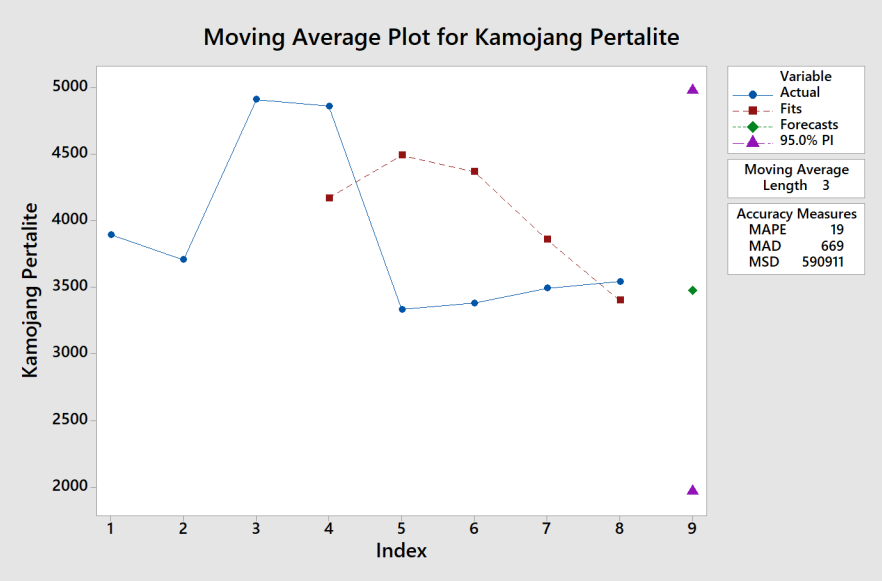

Figure 5. Single Moving Average for Kamojang (Pertalite)

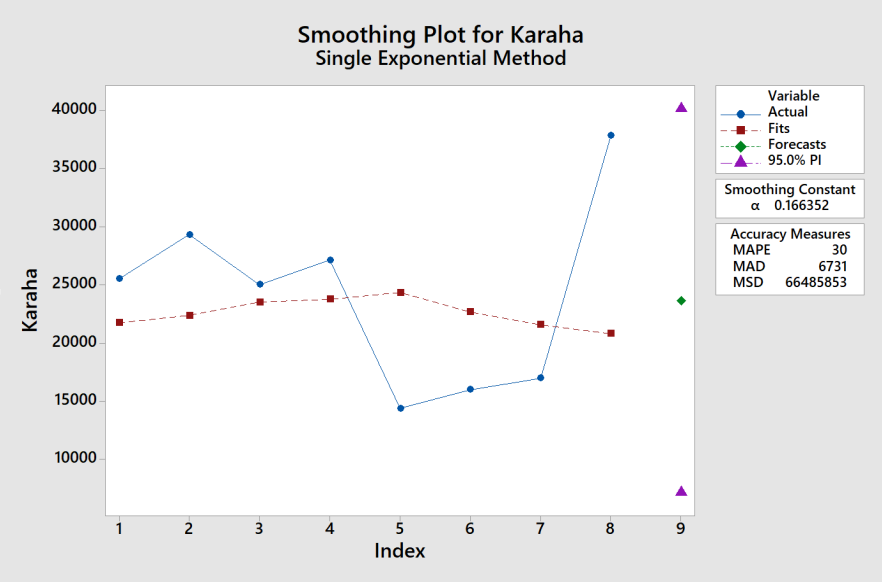

Figure 6. Single Exponential Smoothing for Karaha

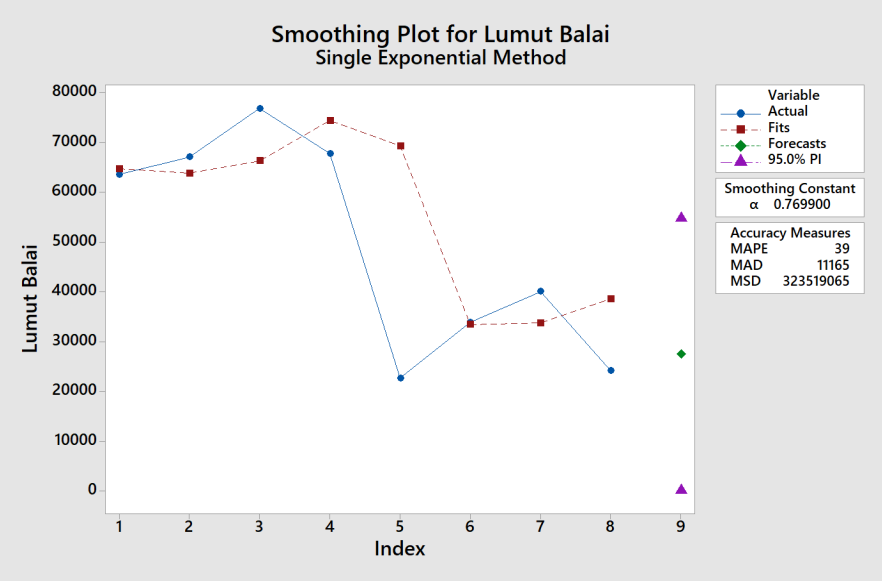

Figure 7. Single Exponential Smoothing for Lumut Balai

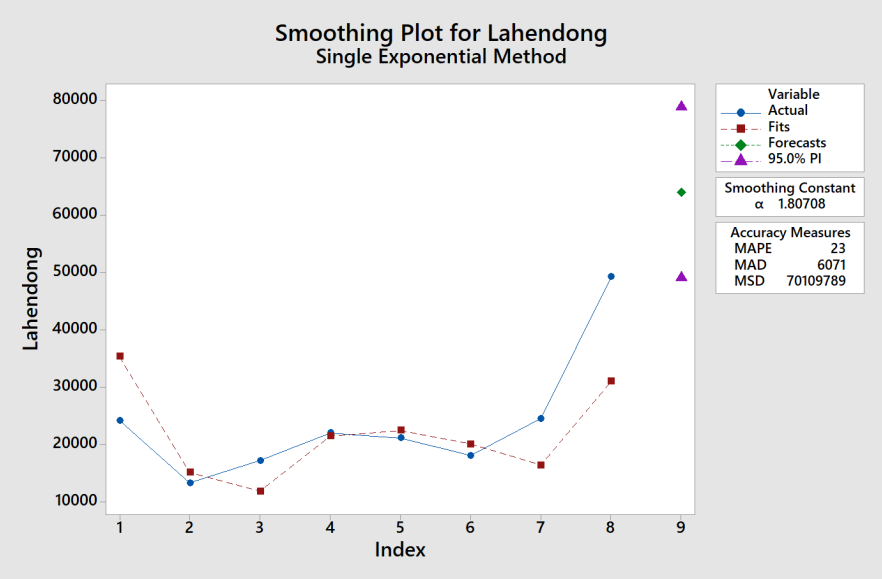

Figure 8. Single Exponential Smoothing for Lahendong

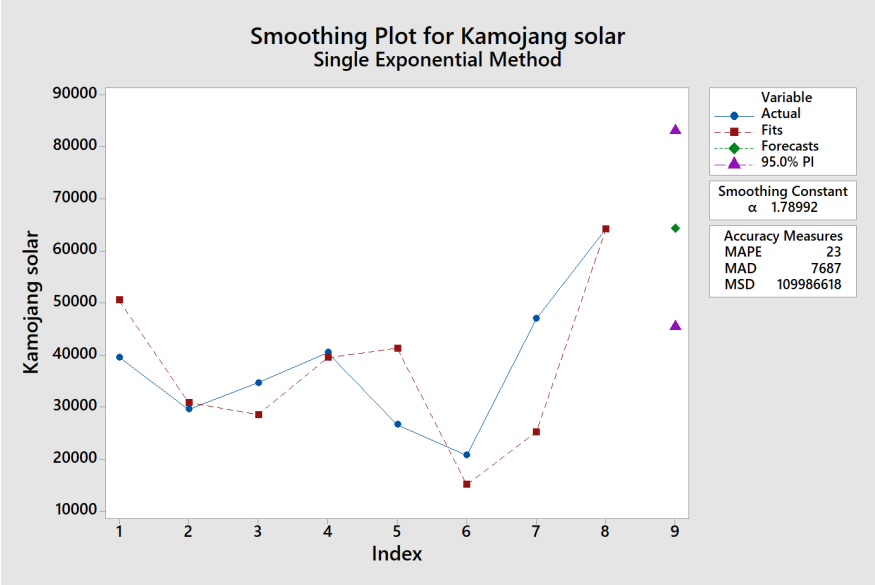

Figure 9. Single Exponential Smoothing for Kamojang (Diesel)

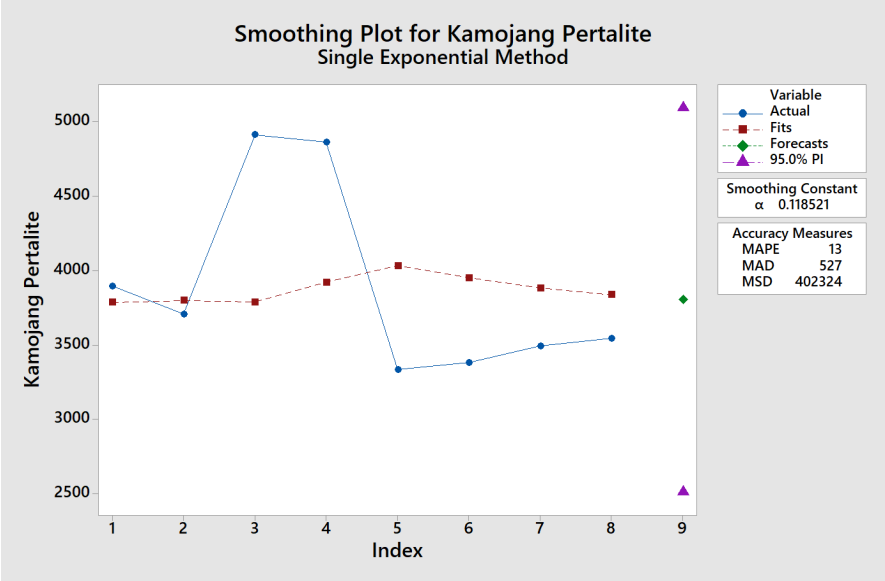

Figure 10. Single Exponential Smoothing for Kamojang (Pertalite)

The graphical results presented are for both Single Moving Average and Single Exponential Smoothing on each area project. We decided to divide the data of two years into eight periods, which means a quarter per year. We use the MA length of 3 and 95% of Prediction Intervals. We use the Minitab software to perform the single exponential smoothing with automated optimum parameters. In the referred process, it is the value of α, which varies for each area.

5.3 Proposed Improvements

According to the comparison between both the Single Moving Average Method and Single Exponential Smoothing Method, we decided that PT. Pertamina Geothermal Energy (PGE) Company would have a better forecast by using Single Exponential Smoothing Method. We are assured that the Single Exponential Smoothing Method is the better

method because it generally has better accuracy, judging from the measure of MAPE, MAD, and MSD. With that being said, the company still needs to examine and compare the forecast with the actual data, then decide again which forecasting method is the closest to the factual data.

5.4 Validation

The quality and error rate of a qualitative forecast result can be known by looking at several variables such as MAPE, MAD, and MSD. From the forecast results that we have obtained for the four geothermal energy extracting areas from the PGE company, the accuracy values of MAPE, MAD, and MSD are shown in the table below

a. Karaha

Table 7. Karaha Forecast Measurement

Consumption Projection	Single Moving Average (Liters)	Single Exponential Smoothing (Liters)
MAPE	40	30
MAD	8.748	6.731
MSD	138.847.189	66.485.853

b. Lumut Balai

Table 8. Lumut Balai Forecast Measurement

Consumption Projection	Single Moving Average (Liters)	Single Exponential Smoothing (Liters)
MAPE	63	39
MAD	16.135	11.165
MSD	568.141.883	323.519.065

c. Lahendong

Table 9. Lahendong Forecast Measurement

Consumption Projection	Single Moving Average (Liters)	Single Exponential Smoothing (Liters)
MAPE	24	23
MAD	8.323	6.071
MSD	166.735.812	70.109.789

d. Kamojang (Diesel)

Table 10. Kamojang (Diesel) Forecast Measurement

Consumption Projection	Single Moving Average (Liters)	Single Exponential Smoothing (Liters)
MAPE	40	23
MAD	15.554	7.687
MSD	332.249.164	109.986.618

e. Kamojang (Pertalite)

Table 11. Kamojang (Pertalite) Forecast Measurement

Consumption Projection	Single Moving Average (Liters)	Single Exponential Smoothing (Liters)
MAPE	19	13
MAD	669	527
MSD	590.911	402.324

The percentage error of a forecast result can be seen through the MAPE value. The higher the MAPE value of a forecast result, the higher the percentage error of the forecast result, and vice versa. The range of effective and still relatively low MAPE values can be seen in the table (table no.) below. From all forecast results that have been carried out in the four geothermal energy extraction areas, it can be seen that the Single moving average method has an average MAPE value of 37.2 and the single exponential smoothing method has an average MAPE value of 25.6. If we look at the exact MAPE value of all geothermal energy extraction areas, it can be seen that single exponential smoothing always has a lower MAPE value than the single moving average. From this value, referring to the table (no table) below, both methods are still classified as Decent forecasting model abilities. However, it can be concluded that single exponential smoothing has a smaller error percentage than the single moving average in this case.

In addition, if we also compare the MAD and MSD values of the two methods, Single exponential smoothing always has the lowest value of both measurements in the four regions compared to the single moving average. Thus, it can be concluded and strengthened that forecasts on the use of PT. Pertamina Geothermal Energy (PGE) fuel consumption in the first quartile of 2022 is more accurate using single exponential smoothing compared to forecasts using single moving averages. However, the fact is that if we do a forecast, it will definitely have an error value and cannot be 100% accurate. So the smaller the error value of a forecast result, the better and more accurate.

Table 12. MAPE Value Range and the Interpretation

MAPE Value Range	**Interpretation**
< 10 %	Very good forecasting model ability
10 - 20 %	Good forecasting model ability
20 - 50 %	Decent forecasting model ability
> 50 %	Bad forecasting model ability

6. Conclusion

From our analysis, we obtain the data for MAPE by using the Single Moving Average method in PT. Pertamina Geothermal Energy (PGE) project area which includes Karaha, Lumut Balai, Lahendong, Kamojang (diesel), and Kamojang (pertalite) to be 40, 63, 24, 40,19 respectively, while using Single Exponential Smoothing we obtain the data to be 30, 39, 23, 23, 13 respectively. The verdict is that all of the area project fuel consumption has lower MAPE with the Single Exponential Smoothing method compared to the Single Moving Average method. It means that the Single Exponential Smoothing method has a lower rate of error than the Single Moving Average method, hence our conclusion is that the Single Exponential Smoothing method is the most accurate method of forecasting in PT. Pertamina Geothermal Energy (PGE).

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Biography

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