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# ANALYSIS OF INDONESIA'S OIL PRODUCTION AND CONSUMPTION USING LAGRANGE POLYNOMIAL INTERPOLATION WITH MATLAB

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**ABSTRACT**

This study aims to examine patterns of oil production and consumption in Indonesia using the Lagrange polynomial interpolation method with the assistance of MATLAB R2025b software. The data used consists of secondary data on Indonesia's oil production and consumption from Worldometer, covering the period 2016–2024. This study employs a quantitative approach using interpolation analysis techniques to estimate values at time points not available in the original data, thereby providing a more continuous picture of the data dynamics. The results show that the Lagrange polynomial interpolation method is capable of producing a smooth, continuous curve that passes through all observation points, thus providing a good level of approximation and closely matching actual values. The analysis shows that oil production in Indonesia tends to decline despite fluctuations in certain periods, specifically from 940,999 barrels per day in 2016 to 840,868 barrels per day in 2024 (a decrease of approximately 10.6%), while oil consumption shows an upward trend, rising from 1,527,215 barrels per day in 2016 to 1,626,878 barrels per day in 2024 (an increase of approximately 6.5%). Furthermore, oil consumption has consistently exceeded production, with the gap ranging from 517,691 barrels per day (2020) to 800,657 barrels per day (2018), indicating a gap between national energy needs and domestic production capacity. These findings indicate that the Lagrange polynomial interpolation method is effective in modeling numerical data and capable of providing an overview of the national energy situation, thereby serving as an analytical tool to support planning and policymaking in the energy sector.

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## 1. INTRODUCTION

Oil demand is a key factor in supporting a country's economic activities and development. Oil consumption continues to rise in tandem with population growth, industrialization, and rapid technological advancements. As a developing country, Indonesia remains heavily dependent on fossil fuels, particularly crude oil, to meet its energy needs [1]. However, rising oil consumption is not always matched by an increase in domestic production, which has the potential to create an imbalance between energy demand and supply. This imbalance can put pressure on the national economy, particularly in terms of increased energy import costs [2]. In an effort to understand this situation, oil production and consumption data are generally available only in discrete form that is, as annual values at specific observation points so information for the periods between two observation points is unavailable. This limitation of discrete data poses a major problem: it necessitates the estimation of values between observation points so that the dynamics of oil production and consumption can be analyzed in greater detail and on a continuous basis.

On a global scale, the United States is the world's largest oil-producing country, with production reaching 22.84 million barrels per day in 2024, followed by Saudi Arabia and Russia [3]. Meanwhile, Indonesia's situation is quite different: it produced only about 840,868 barrels per day in 2024, according to Worldometer's data which uses the definition of total oil production placing it 23rd in the world, while its consumption reached 1,626,878 barrels per day [4]. This gap between production and consumption means Indonesia must continue to rely on large volumes of oil imports. Indonesia's crude oil imports reached 321,917 barrels per day in 2024, with an upward trend since 2021 [5]. To provide an overview of the development of oil imports in Indonesia, import data from 2016 to 2024 are presented in Table 1.

**Table 1**. Data on Indonesia's Crude Oil Imports

| Year | Crude Oil Imports (barrels per day) |
|---|---|
| 2016 | 366.070 |
| 2017 | 343.750 |
| 2018 | 335.833 |
| 2019 | 209.167 |
| 2020 | 231.583 |
| 2021 | 206.333 |
| 2022 | 311.167 |
| 2023 | 332.750 |
| 2024 | 321.917 |

Source: CEIC

This reliance on imports is also linked to a decline in domestic oil production caused by aging wells, a lack of new exploration, and uncertainty surrounding oil and gas policies [6]. In terms of refining capacity, Indonesia currently has a total oil refinery capacity of 1.218 thousand barrels per day spread across eight operational refineries, with the largest refineries located in Balikpapan (360 thousand barrels/day) and Cilacap (348 thousand barrels/day) [7]. This highlights the challenges in meeting domestic oil demand and maintaining a balance between production, consumption, and oil refining capacity in Indonesia.

According to data from Worldometer, oil consumption in Indonesia has shown an upward trend over time, while oil production has tended to remain stagnant.

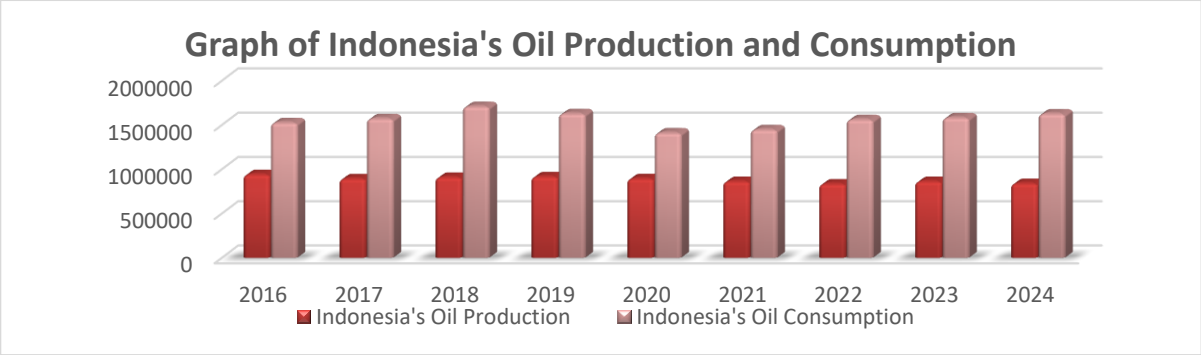



**Figure 1.** Chart of Oil Production and Consumption in Indonesia
Source: Worldometer

This situation has caused the gap between oil demand and supply to widen further, potentially increasing dependence on oil imports and affecting national energy stability. Therefore, further analysis of this data is needed to understand the emerging patterns and obtain interpolated values for specific periods.

When analyzing oil consumption and production data, a mathematical approach is needed that can provide accurate estimates. Ideally, data analysis should be conducted continuously and comprehensively for every time period. However, available data is generally discrete, collected at specific time intervals, and thus does not always provide information at every desired point. This limitation makes it difficult to conduct detailed trend analysis or estimate values for unobserved periods [8]. Therefore, numerical methods are needed to approximate values between the available data points.

Of all the available numerical approaches, Lagrange polynomial interpolation was chosen because it can construct a single polynomial function that passes through all historical data points, ensuring

that the resulting estimates are consistent with the reference data [8]. This method is more suitable than regression, which only produces an average approximation curve, and is simpler than spline and Newton's interpolation, which require data segmentation or the compilation of a table of successive differences. Compared to ARIMA, which requires stationarity and a large number of observations, Lagrange does not require any assumptions about the data distribution and can still be applied to limited annual data. Furthermore, empirical evidence shows that this method can be used to predict population growth with stable results on numerical data with a limited number of data points [9].

Previous studies have applied the Lagrange polynomial interpolation method in various fields. A study by [10] showed that this method can be used to predict demand in the printing industry with a high degree of accuracy, particularly when historical data is limited. Additionally, [11] demonstrated that the Lagrange interpolation method can produce predicted values that closely approximate actual data in time-series analysis. Another study by [1] also showed that this method is effective for predicting numerical data with a relatively small margin of error. The use of software such as MATLAB R2025b can help make the numerical calculation and data visualization processes more efficient and systematic [12].

Despite this, the application of the Lagrange polynomial interpolation method in energy data analysis particularly for approximating oil consumption and production in Indonesia remains relatively limited. Energy research to date has predominantly relied on time-series models such as ARIMA or dynamic systems for forecasting energy trends [13]. Furthermore, previous studies have generally applied the method to only a single type of data and have not addressed the limitations of the polynomial degree or the potential for numerical oscillations (the Runge phenomenon), which are relevant when this method is applied to long-term annual data. Therefore, this study fills this gap by applying Lagrange polynomial interpolation separately to Indonesia's oil production and consumption data for the 2016–2024 period to generate semi-annual estimates for each variable. This approach enables a more continuous analysis of domestic energy imbalance patterns while expanding the application of the Lagrange interpolation method to two interrelated energy variables.

Oil consumption and production were selected as variables in this study because they are key indicators of a country's energy situation. Oil consumption reflects the level of national energy demand, while oil production indicates a country's ability to meet that demand independently [14]. An imbalance between these two variables can lead to increased dependence on oil imports and affect economic stability. Therefore, analyzing these two variables is crucial for understanding a country's energy situation and supporting sound energy planning.

This study therefore aims to implement the Lagrange polynomial interpolation method using MATLAB R2025b to approximate oil consumption and production data in Indonesia based on data obtained from Worldometer. This study is expected to contribute to the development of numerical analysis, particularly in the application of the Lagrange polynomial interpolation method to energy data, as well as to serve as an alternative mathematical approach for analyzing oil consumption and production in Indonesia.

## 2. RESEARCH METHOD

This study employs a quantitative approach focused on the implementation of a numerical method, namely Lagrange Polynomial Interpolation [15]. The quantitative approach was chosen because this study focuses on the processing of numerical data in the form of oil production and consumption data in Indonesia. This study falls under the category of numerical projection, as it aims to project a value based on historical data using a systematic mathematical approach.

The data used in this study consists of secondary data on crude oil production and consumption in Indonesia, measured in barrels per day. The data was sourced from the global statistics website Worldometer. The oil production variable used is total oil production as defined by Worldometer, which includes crude oil and other hydrocarbon liquids and thus differs from crude oil production alone, while the oil consumption variable is total oil consumption. The data collected includes oil production and consumption figures for Indonesia from 2016 to 2024, gathered through a literature review of statistical publications available on the website. The data was then organized by year of observation to facilitate the analysis process

The analytical technique used in this study employs the Lagrange polynomial interpolation method with the aid of MATLAB R2025b software to perform numerical calculations and graphical visualization. Lagrange interpolation is a method used to determine a polynomial that passes through all known data points [16]. Suppose there are a number of data points $(x_0, y_0), (x_1, y_1), \dots, (x_n, y_n)$ then the Lagrange interpolation polynomial can be expressed as follows [17].

$$P_n(x) = \sum_{i=0}^{n} y_i L_i(x)$$

using the Lagrange basis function:

$$L_i(x) = \prod_{j=0, j\neq i}^{n} \frac{x - x_j}{x_i - x_j}$$

Notes:
$P_n(x)$ : interpolation polynomial.
$x_i$ : value of the independent variable at a data point.
$y_i$ : value of the function at a data point.
$L_i(x)$ : Lagrange basis polynomial.

The data analysis process began with the collection of data on Indonesia's oil production and consumption for the 2016–2024 period, obtained from the Worldometer website. The collected data was then screened and organized into tables by observation year to ensure data consistency and completeness. Next, the data was processed using the Lagrange polynomial interpolation method with the aid of MATLAB R2025b software to generate a polynomial that passes through all available data points. The resulting polynomial was then used to calculate estimated values and identify trends in Indonesia's oil production and consumption. The results were visualized in graph form to compare the original data with the interpolated results, allowing for an analysis of data trends over the study period.

To evaluate the interpolation capability in estimating data values not used in the formation of the polynomial, this study employs the Leave-One-Out Cross-Validation (LOOCV) method. In each iteration, one data point is removed from the dataset and used as test data, while the remaining data points are used as training data to form the Lagrange interpolation polynomial. The resulting polynomial is then used to estimate the value at the excluded data point. This process is repeated until every data point has served as test data [18]. Next, the estimated values are compared with the actual values to calculate the Mean Absolute Error (MAE) and Root Mean Square Error (RMSE) as measures of interpolation error.

$$MAE = \frac{1}{\mathrm{n}} \sum_{i=0}^{n} | y_i - \hat{y}_i |$$

$$\mathrm{RMSE} = \sqrt{\frac{1}{\mathrm{n}} \sum_{i=0}^{n} | y_i - \hat{y}_i |}$$

Notes:
$y_i$ = actual value
$\hat{y}_i$ = LOOCV estimated value
$n$ = number of data points

## 3. RESEARCH RESULTS AND DISCUSSION

### 3.1 Research result

The data used in this study consist of two variables: year as the independent variable (x), and oil production and oil consumption as the dependent variables (y). The data were collected over the period from 2016 to 2024, so each value for oil production and consumption represents conditions in a specific year.

**Table 2**. Data on Oil Production and Consumption in Indonesia

| Year | Indonesia's Oil Production | Indonesia's Oil Consumption |
|---|---|---|
| 2016 | 940.999 | 1.527.215 |
| 2017 | 893.717 | 1.572.303 |
| 2018 | 909.465 | 1.710.140 |
| 2019 | 916.777 | 1.629.452 |
| 2020 | 894.691 | 1.412.382 |
| 2021 | 863.665 | 1.448.476 |
| 2022 | 835.159 | 1.562.115 |
| 2023 | 863.236 | 1.582.985 |
| 2024 | 840.868 | 1.626.878 |

The analysis of oil production and consumption data was conducted using the Lagrange polynomial interpolation method as an approach to model the available data. This method was chosen because it can numerically estimate oil production and consumption values based on a set of known data points by constructing an 8th-degree polynomial derived from 9 data points on oil production and consumption (2016–2024). Next, values will be estimated for the half-year intervals for which data are not yet available, specifically from 2016.5 through 2023.5.

**Analysis of Oil Production Data**

The calculations and simulations of oil production data were performed using the MATLAB program shown in the figure below.

```
x = [2016 2017 2018 2019 2020 2021 2022 2023 2024];
y = [940999 893717 909465 916777 894691 863665 835159 863236 840868];

n = length(x);

% Array untuk titik yang akan diprediksi
xp_values = 2016.5:0.5:2023.5; % Interval 0.5 tahun dari 2016.5 hingga 2023.5
predictions = zeros(size(xp_values)); % Array untuk menyimpan hasil prediksi

% Loop untuk menghitung interpolasi di setiap xp
for k = 1:length(xp_values)
    xp = xp_values(k); % Tahun yang sedang dihitung
    sm = 0; % Inisialisasi hasil interpolasi

    for i = 1:n
        pr = 1; % Inisialisasi produk
        for j = 1:n
            if j ~= i
                pr = pr * (xp - x(j)) / (x(i) - x(j));
            end
        end
        sm = sm + y(i) * pr; % Tambahkan ke jumlah akhir
    end

    predictions(k) = sm; % Simpan hasil prediksi
end

% Tampilkan hasil
disp('Prediksi populasi:')
for k = 1:length(xp_values)
    disp(['Tahun ', num2str(xp_values(k)), ' : ', num2str(predictions(k))])
end
```

**Figure 2.** Script for Calculating Indonesia's Oil Production Data Using MATLAB R2025b

The following data on oil production in Indonesia from 2016 to 2024, presented on a semi-annual basis, is not yet available and has been included in Table 3.

**Table 3.** Oil Production by Half-Year (2016–2024)

| Year | Indonesia's Oil Production |
|---|---|
| 2016.5 | 912503.7319 |
| 2017.5 | 897043.8545 |
| 2018.5 | 917802.2299 |
| 2019.5 | 907827.1435 |
| 2020.5 | 879812.4975 |
| 2021.5 | 847135.999 |
| 2022.5 | 837823.2221 |
| 2023.5 | 894457.0459 |

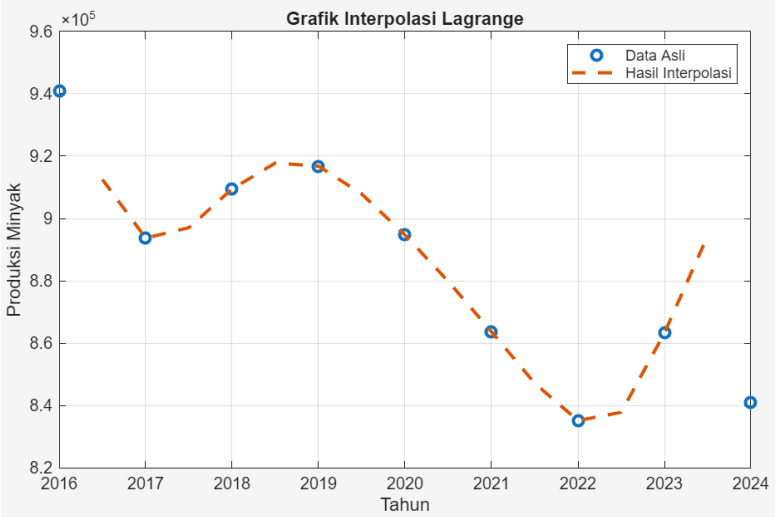



**Figure 3.** Graph of Lagrange Interpolation Results

**Analysis of Oil Consumption Data**

The calculations and simulations of oil production data were performed using the MATLAB program shown in the figure below.

```
x = [2016 2017 2018 2019 2020 2021 2022 2023 2024];
y = [1527215 1572303 1710140 1629452 1412382 1448476 1562115 1582985 1626873];

n = length(x);

% Array untuk titik yang akan diprediksi
xp_values = 2016.5:0.5:2023.5; % Interval 0.5 tahun dari 2016.5 hingga 2023.5
predictions = zeros(size(xp_values)); % Array untuk menyimpan hasil prediksi

% Loop untuk menghitung interpolasi di setiap xp
for k = 1:length(xp_values)
    xp = xp_values(k); % Tahun yang sedang dihitung
    sm = 0; % Inisialisasi hasil interpolasi

    for i = 1:n
        pr = 1; % Inisialisasi produk
        for j = 1:n
            if j ~= i
                pr = pr * (xp - x(j)) / (x(i) - x(j));
            end
        end
        sm = sm + y(i) * pr; % Tambahkan ke jumlah akhir
    end

    predictions(k) = sm; % Simpan hasil prediksi
end

% Tampilkan hasil
disp('Prediksi populasi:')
for k = 1:length(xp_values)
    disp(['Tahun ', num2str(xp_values(k)), ' : ', num2str(predictions(k))])
end
```

**Figure 4.** Script for Calculating Indonesia's Oil Consumption Data Using MATLAB R2025b

The following data on Indonesia's oil consumption for 2016–2024 was used as the basis for interpolation calculations to obtain values for the half-year intervals for which data is not yet available.

**Table 4.** Oil Consumption by Half-Year (2016–2024)

| Year | Indonesia's Oil Consumption |
|---|---|
| 2016.5 | 1604922.0791 |
| 2017.5 | 1632165.2846 |
| 2018.5 | 1714915.747 |
| 2019.5 | 1504762.5405 |
| 2020.5 | 1396150.7939 |
| 2021.5 | 1520748.0034 |
| 2022.5 | 1565339.7197 |
| 2023.5 | 1661697.1108 |

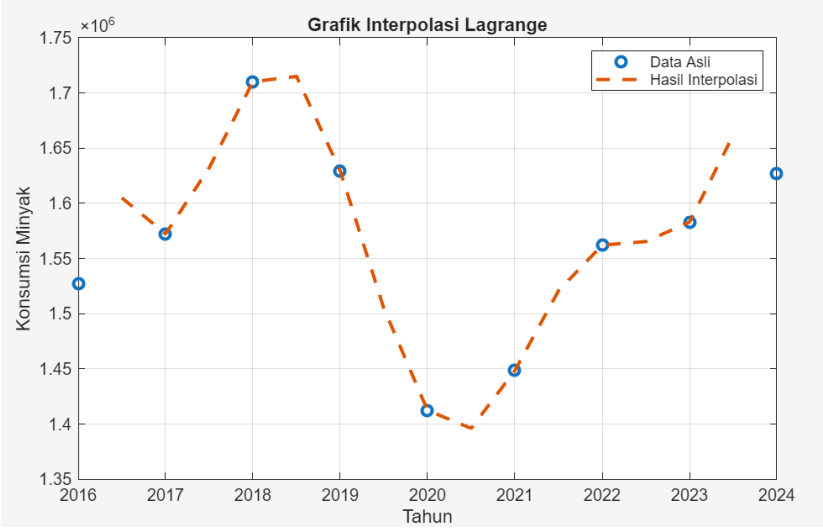



***Figure 5.*** *Graph of Lagrange Interpolation Results*

**Accuracy Analysis of Lagrange Interpolation Using Leave-One-Out Cross-Validation (LOOCV)**

An accuracy analysis was conducted to determine the ability of the Lagrange interpolation method to produce estimates that approximate the actual values. Although Lagrange polynomials, by their very construction, pass through all data points used as nodes, this condition alone does not indicate the method's level of accuracy. Therefore, the evaluation was performed using Leave-One-Out Cross-Validation (LOOCV), in which one data point is sequentially removed from the interpolation nodes, and the value at that point is then predicted using the remaining data points. The method's performance was subsequently evaluated using Mean Absolute Error (MAE) and Root Mean Square Error (RMSE).

**Table 5.** LOOCV Results for Indonesian Oil Production Data

| Test year | Present Value | LOOCV Prediction | Error | Absolute Error | Squared Error |
|---|---|---|---|---|---|
| 2016 | 940.999 | 1.441.666,00 | −500.667,00 | 500.667,00 | 250.667.444.889,00 |
| 2017 | 893.717 | 831.133,63 | 62.583,38 | 62.583,38 | 3.916.678.826,39 |
| 2018 | 909.465 | 927.345,96 | −17.880,96 | 17.880,96 | 319.728.883,79 |
| 2019 | 916.777 | 907.836,52 | 8.940,48 | 8.940,48 | 79.932.220,95 |
| 2020 | 894.691 | 901.843,39 | −7.152,39 | 7.152,39 | 51.156.621,41 |
| 2021 | 863.665 | 854.724,52 | 8.940,48 | 8.940,48 | 79.932.220,95 |
| 2022 | 835.159 | 853.039,96 | −17.880,96 | 17.880,96 | 319.728.883,79 |
| 2023 | 863.236 | 800.652,63 | 62.583,38 | 62.583,38 | 3.916.678.826,39 |
| 2024 | 840.868 | 1.341.535,00 | −500.667,00 | 500.667,00 | 250.667.444.888,99 |

Based on the Absolute Error values in Table 5, the Mean Absolute Error (MAE) was calculated to be 131,921.78 barrels/day. This value was obtained by averaging all the Absolute Error values at the nine test points. Furthermore, based on the Squared Error values at each test point, the Root Mean Square Error (RMSE) was calculated to be 238,051.98 barrels per day. The largest Absolute Error values occurred in 2016 and 2024, at 3,962,299.00 barrels per day each.

**Table 6.** LOOCV Results for Indonesian Oil Consumption Data

| Test year | Present Value | LOOCV Prediction | Error | Absolute Error | Squared Error |
|---|---|---|---|---|---|
| 2016 | 1.527.215 | 5.489.514,00 | -3.962.299,00 | 3.962.299,00 | 15.699.813.365.401,00 |
| 2017 | 1.572.303 | 1.077.015,63 | 495.287,38 | 495.287,38 | 245.309.583.834,39 |
| 2018 | 1.710.140 | 1.851.650,68 | -141.510,68 | 141.510,68 | 20.025.272.149,75 |
| 2019 | 1.629.452 | 1.558.696,66 | 70.755,34 | 70.755,34 | 5.006.318.037,44 |
| 2020 | 1.412.382 | 1.468.986,27 | -56.604,27 | 56.604,27 | 3.204.043.543,96 |
| 2021 | 1.448.476 | 1.377.720,66 | 70.755,34 | 70.755,34 | 5.006.318.037,44 |
| 2022 | 1.562.115 | 1.703.625,68 | -141.510,68 | 141.510,68 | 20.025.272.149,75 |
| 2023 | 1.582.985 | 1.087.697,63 | 495.287,37 | 495.287,37 | 245.309.583.834,39 |
| 2024 | 1.626.878 | 5.589.177,00 | -3.962.299,00 | 3.962.299,00 | 15.699.813.365.400,90 |

Based on the Absolute Error values in Table 6, the Mean Absolute Error (MAE) was calculated to be 1,044,034.34 barrels/day. This value was obtained by averaging all the Absolute Error values at the nine test points. Furthermore, based on the Squared Error values at each test point, the Root Mean Square Error (RMSE) was calculated to be 1,883,953.09 barrels per day. The largest Absolute Error values occurred in 2016 and 2024, at 3,962,299.00 barrels per day each.

In this study, LOOCV evaluation was used to assess the performance of the Lagrange interpolation method in estimating values at observation points not used in the polynomial fitting. Meanwhile, the interpolation results for the midpoints between 2016.5 and 2023.5 are still presented as the primary estimation results because those points lack actual observed values for comparison. Thus, LOOCV is used as a supplementary evaluation to provide information regarding the Lagrange method's ability to reconstruct observed values that were excluded from the polynomial fitting process.

### 3.2 Discussion

Based on the resulting interpolation graph, the Lagrange polynomial curve closely follows the trend and the original data. The interpolation line, which takes the form of a smooth curve, shows a continuous relationship between the data points, making this method effective for estimating values between observation points that are not available in the original data. However, it should be noted that the use of high-degree polynomial interpolation has the potential to produce oscillations at certain points. In global polynomial interpolation, this condition is known as the Runge phenomenon, which

can occur if too many data points are used or if the data exhibits large fluctuations, causing the resulting numerical solution to become less stable [19]. Therefore, the use of high-degree polynomials is generally more suitable for interpolation over a limited data range.

Overall, the results of this study indicate that the Lagrange polynomial interpolation method can be used as a mathematical approach to model Indonesia's oil production and consumption over a specific time interval. With estimates available for shorter intervals, energy consumption trends can be analyzed in greater detail, thereby providing additional information for national energy planning studies. In practice, the accuracy of the interpolation results is also influenced by the selection of data points used in the calculation process.

This is consistent with research conducted by [20], which explains that in the interpolation process involving a relatively large amount of data, data points should be selected by forming intervals that are homogeneous or have equal distances between points. Selecting points with relatively small distances between them ensures that the resulting polynomial remains stable and can represent the data pattern more accurately, thereby preventing the interpolation results from experiencing excessive value spikes. By adhering to this principle, the interpolation process in this study produces calculations that closely approximate the actual data pattern.

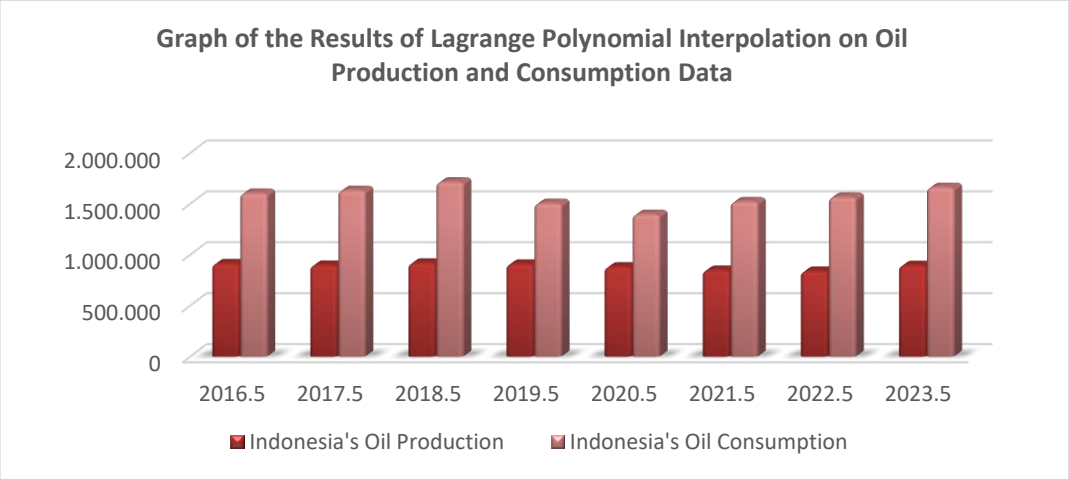



**Figure 6.** Diagram Showing the Results of Lagrange Polynomial Interpolation on Indonesia's Oil Production and Consumption Data

The results of calculations using this method also show a pattern consistent with the actual data from Worldometer, which reveals a disparity between oil production and consumption in Indonesia. The graph of the interpolated results shows that oil consumption tends to be higher than production levels, indicating a gap between domestic energy needs and the country's oil production capacity.

The phenomenon of oil consumption exceeding production in Indonesia is influenced by various factors within the energy sector. One of the main causes is the downward trend in domestic oil production due to depleting oil reserves and limited discoveries of new reserves [21]. In addition, low reserve replacement rates and various technical and non-technical constraints such as declining productivity at aging oil fields, operational disruptions, and the complexity of the permitting process also hinder efforts to increase domestic oil production. These conditions have resulted in domestic oil production being unable to keep pace with ever-increasing consumption needs [22].

On the other hand, oil consumption in Indonesia continues to rise, driven by population growth, industrial development, and increasing national economic activity. Crude oil remains the primary energy source used in various sectors such as transportation, industry, and households so demand tends to increase every year. High dependence on fossil fuels and the suboptimal development of alternative energy sources are further widening the gap between oil production and consumption [23]. As a result, domestic oil production has not been able to meet national energy needs, so this supply shortfall must be covered through oil imports [2].

Research results from [23] also reinforce these findings, indicating that Indonesia's oil consumption is projected to remain above its production level for the next several years. This imbalance indicates a potential energy deficit that could impact the national economy if not counterbalanced by appropriate policies for energy management and increased domestic production. Thus, the interpolation results not only mathematically describe the data patterns but also reflect the actual conditions of Indonesia's energy sector namely, that domestic energy demand still exceeds the country's oil production capacity.

To address this imbalance between oil production and consumption, the Indonesian government has undertaken various efforts, one of which is the implementation of Enhanced Oil Recovery (EOR) technology an advanced method for optimizing the extraction of oil remaining in reservoirs that cannot be recovered through conventional methods [24]. On the other hand, the government is also promoting long-term energy transition policies by reducing dependence on fossil fuels and increasing the use of new and renewable energy through regulations such as the National Energy Policy (KEN) and the National Energy Master Plan (RUEN) [25]. Nevertheless, the implementation of these policies still faces various challenges, such as limited investment, inadequate infrastructure, and high dependence on fossil fuels [25]; therefore, these efforts must continue to be strengthened to ensure national energy security in the future.

In addition to describing oil production and consumption patterns, this study also evaluates interpolation performance using Leave-One-Out Cross-Validation (LOOCV). The evaluation results show differences in interpolation error rates between oil production and consumption data. For the production data, the MAE was 131,921.78 barrels/day and the RMSE was 238,051.98 barrels/day, with the MAE equivalent to approximately 15% of the average actual value. Meanwhile, for consumption data, the MAE was 1,044,034.34 barrels/day and the RMSE was 1,883,953.09 barrels/day, with the MAE equivalent to about 67% of the average actual value. This comparison shows that the interpolation error relative to the data scale is smaller for production data than for consumption data.

The fact that the RMSE values are larger than the MAE values on both datasets indicates the presence of several relatively large errors that have a stronger influence on the RMSE values, since RMSE assigns greater weight to large errors [26]. The largest cross-validation errors in both datasets occurred in 2016 and 2024. This happened because when one of the endpoints was excluded during the LOOCV process, that point fell outside the range of the remaining nodes, so the prediction at that point effectively became an extrapolation [27]. This condition can result in greater deviations compared to estimates at points within the node range.

These findings highlight the importance of using validation methods such as LOOCV to evaluate the interpolation capabilities of Lagrange interpolation, since polynomials fitted using all data points will always pass through those points. Therefore, the estimated results at mid-year points particularly those closer to the boundaries of the data range, such as 2016.5 and 2023.5 should be interpreted with consideration of the polynomial's characteristics near the interval boundaries.

## 4. CONCLUSION

Based on the research findings, the Lagrange polynomial interpolation method proved effective for approximating and modeling oil production and consumption data in Indonesia for the 2016–2024 period. The resulting interpolation curves closely follow the patterns of the original data and provide estimates for time intervals for which detailed data are not available. Substantively, oil production tends to decline, while oil consumption shows a relatively increasing trend. The consistent high level of consumption compared to production each year indicates a dependence on oil imports. Thus, this method is not only mathematically useful but also capable of representing the actual conditions of Indonesia's energy sector.

As a recommendation, it is necessary to develop analytical methods that incorporate other numerical techniques to ensure more accurate and stable estimates, particularly when using high-degree polynomials. More optimal data selection and processing are also required to reduce the likelihood of results deviating from reality. From an implementation perspective, the findings of this study are expected to serve as a basis for energy sector policy decisions, particularly in balancing oil production and consumption through increased domestic production and the development of alternative energy sources.

## 5. AUTHOR CONTRIBUTIONS STATEMENT

individual contributions of the authors are described in accordance with the Contributor Roles Taxonomy (CRediT), as presented in Table 7.

**Table 7.** Authors' Contributions According to the CRediT Taxonomy

| Name of Author | C | M | So | Va | Fo | I | R | D | O | E | Vi | Su | P | Fu |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Author 1 | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | | ✓ | ✓ |
| Author 2 | | ✓ | ✓ | | ✓ | ✓ | | ✓ | ✓ | ✓ | | | ✓ | ✓ |
| Author 3 | | | | ✓ | | ✓ | ✓ | | | | ✓ | ✓ | | ✓ |

C : **C**onceptualization
M : **M**ethodology
So : **So**ftware
Va : **Va**lidation
I : **I**nvestigation
R : **R**esources
D : **D**ata Curation
O : Writing - **O**riginal Draft
Vi : **Vi**sualization
Su : **Su**pervision
P : **P**roject administration
Fu : **Fu**nding acquisition

Fo : **Fo**rmal analysis E : Writing - Review & **E**diting

## 6. AI Disclosure Statement

During the writing of this manuscript, the author used DeepL and ChatGPT (OpenAI) for translation and language editing. The author has thoroughly reviewed and revised the content of the manuscript and assumes full responsibility for this publication.

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