TIME SERIES FORECASTING FOR ENERGY CONSUMPTION IN MALAYSIA USING REGRESSION TECHNIQUE

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ABSTRACT

Energy demand forecasting helps organizations and governments make appropriate energy management decisions and formulate relevant economic policy since such countries as Malaysia are categorized as rapidly developing countries. This study uses regression techniques to forecast time series analysis on Malaysia's energy consumption. The goal is to analyze historical energy consumption data, build accurate regressions, and offer recommendations for future energy use. Secondary data was obtained from reliable sources such as national and international databases and covers the total energy consumption, GDP, population, and temperature. Data cleaning and analysis are carried out to examine the correlations and patterns inherent in the data. Building on these regression models involved the application of the performance metrics, including the Mean Absolute Error (MAE), Mean Squared Error (MSE), or Root Mean Squared Error (RMSE). Regularization methods such as Ridge and Lasso were used in the process of model training to reduce overfitting. This proves that received regression models allow for an accurate energy consumption forecast and would be valuable for policymakers and energy planners. The findings of this study are helpful in the sustainability of the energy sector of Malaysia through facilitating the decision-making process on resource management.

CHAPTER 1

INTRODUCTION

1.0 Introduction

In the modern world, the efficient management and planning of energy resources are pivotal for ensuring economic stability and sustainable development. Accurate energy consumption forecasting is essential for rapidly developing countries like Malaysia to address the growing demand and make informed decisions regarding energy production, distribution, and policymaking. As Malaysia continues its journey towards industrialization and urbanization, understanding and predicting energy consumption patterns becomes increasingly complex and vital.

Malaysia's energy landscape has undergone significant changes over the past few decades. The country's energy sector, characterized by a diverse mix of fossil fuels (natural gas, coal, and oil) and renewable energy sources (hydropower, solar, and biomass), has seen substantial growth in demand due to industrial expansion, urban development, and population growth. This rising energy demand presents opportunities and challenges for Malaysia, necessitating sophisticated forecasting methods to ensure energy security, economic efficiency, and environmental sustainability.

Time series forecasting is a well-established method for predicting future values based on historical data. It involves analysing past energy consumption patterns to identify trends, seasonality, and other temporal dynamics. Regression techniques, in particular, are powerful tools in time series forecasting as they model the relationship between energy consumption (the

dependent variable) and various influencing factors (independent variables) such as GDP, population, and temperature.

1.1 Background of the Problem

There are important issues that are also valid and deserve to be highlighted when forecasting energy consumption in Malaysia. Since it is affected, for instance, by economic growth, technological innovation, variation in climate conditions, and changes in policies concerning consumer behaviour, it occasionally becomes difficult to forecast it accurately. Also, gaps, inconsistencies, and delays in reporting significantly decrease the quality and timeliness of the data utilized in forecasting. Furthermore, the change in the pattern of using energy-efficient appliances, progress in the higher technologies used in energy grids, and continual development of grid technology also contribute to the problems that make it challenging to obtain a high level of accuracy in the forecast. Consumer decisions are affected by other policy and regulatory changes regarding subsidies, tariffs, and incentives concerning renewable energy.

1.2 Statement of the problem

Malaysia has been experiencing a rapid rate of economic growth. Thus, coupled with development, it has contributed to the increased use of energy through industrialization, the expansion of urban centres, and the growth of the population base. This increasing energy demand is vital in providing secure, efficient, and sustainable energy systems. Moreover, traditional approaches in forecasting do not capture consumption well mainly because energy consumption is often impacted by several factors, including economic indicators, technological development, and variations in climate, among others; alongside, there are often breaks in data, inaccurate data and delays in reporting data progress making it challenging to come up with accurate forecast data.

Having adequate and precise energy consumption forecasts is vital to enable Malaysia to manage its energy demands and formulate policies. It will enable policymakers and energy planners to make appropriate decisions regarding energy supplies, distribution and generation

investments. With inaccurate forecasting, there might be a lead of energy deficit or excesses, wastage of resources, and failure to attain a new paradigm concerning renewable energy and viable environmental footprints.

This study proposes using advanced regression techniques for time series forecasting to improve the accuracy of energy consumption predictions in Malaysia. Compared to other methods, regression analysis can embrace all the qualities and interconnections within the energy consumption data and the factors affecting it, thus providing more accurate predictions. The findings from this study will help policymakers and energy planners formulate policies that accommodate Malaysia's energy demands through a well-informed analysis of the various energy priorities that can contribute to the country's balanced energy mix.

1.3 Research Questions

1) How effective are different regression techniques (linear, polynomial, multiple linear regression) in forecasting energy consumption in Malaysia?
2) How do advanced regression models compare to traditional time series forecasting methods regarding accuracy and reliability?
3) What are the potential impacts of implementing energy efficiency measures on future energy consumption in Malaysia?
4) What are the potential future trends in energy consumption in Malaysia based on current data and regression model predictions?

1.4 Research Objectives

1) To collect and analyse historical data on energy consumption in Malaysia to identify trends, patterns, and seasonal variations.
2) To develop regression models (linear, polynomial, multiple linear regression) for forecasting future energy consumption in Malaysia.
3) To evaluate the performance of different regression models using metrics such as Mean Absolute Error (MAE), Mean Squared Error (MSE), and Root Mean Squared Error (RMSE).

1.5 Scope of the study

In forecasting energy consumption in Malaysia, this study employs regression techniques with several essential aspects to ensure a comprehensive approach. Therefore, the empirical coverage of the research is nationwide, involving states and regions in the country, both urban and rural, hence offering a consolidated view of energy consumption. The time frame includes historical energy consumption data for several decades to capture long-term trends, seasonality, and potential cyclical patterns, as well as data projections for the near future (up to 5-10 years) valid in short and medium-term energy planning.

Data will be sourced from reputable national and international databases, including the Energy Commission of Malaysia, the Department of Statistics Malaysia, Tenaga National Berhad, the Climate Change Knowledge Portal and global organizations such as the International Energy Agency (IEA) and the World Bank. The study will incorporate various types of data, such as total energy consumption, sector-specific consumption, economic indicators (GDP), consumer price index (CPI), demographic data (population growth), and climatic variables (temperature, humidity).

Methodologically, in this study, different types of regression analysis, such as linear regression, polynomial regression, and multiple linear regression, will be applied. Data pre-processing will involve data cleansing, transformation, and feature engineering to fit the data set into the model. Exploratory Data Analysis (EDA) will uncover hidden structures and relationships in the dataset to be analysed. Model evaluation metrics like Mean Absolute Error (MAE), Mean Squared Error (MSE), and Root Mean Squared Error (RMSE) will be used, and cross-validation techniques will be employed to ensure the models' reliability and applicability are tested.

The study will also compare and determine the extent of contributions from specific economic, demographic and climatic variables on energy consumption. Scenario analysis will clarify how changes in economic and environmental conditions in the future can impact energy consumption and what impact policy changes regarding energy efficiency measures and the promotion of renewable energy can have.

The insight will help inform policymakers and assist the planning process for energy needs in Malaysia by making recommendations that will secure energy availability, be economically rational from a global perspective, and respect environmental limits. The study will also state significant limitations, including data availability and quality and unpredictable future energy patterns. However, it will offer recommendations on how future studies can minimize these limitations and provide a much better understanding of energy consumption patterns. This scope aims to provide helpful information to understand better energy management and decision-making on energy policies within Malaysia's society.

1.6 Significant of the Research

The study on time series forecasting for energy consumption in Malaysia based on regression techniques is crucial for various and essential stakeholders, such as the government, energy planners, and the public. Accurate energy consumption forecast estimations facilitate the reliability of an efficient energy supply. As a result, this study is helpful in the timely distribution of energy resources since types of energy with high demand will have to be produced while those with low demand will have to be too stockpiled since their demand is low. The outcomes of this study can help policymakers come up with the right policies regarding energy. Estimating the change in energy demand for successive years helps formulate and implement energy conservation measures, efficient growth, and energy-renewable transformation.

Energy consumption forecasts can help reduce the production costs for energy, promoting improvement in Malaysia's energy sector's performance and competitiveness. Moreover, it is crucial to generate robust forecasts to help Malaysia address its obligations on greenhouse gas emission reduction and climate change mitigation. The study can inform the forecast and incorporation of renewable energy sources and take prompt actions on energy conservation, and with these aspects, the research can enhance the environment.

The application of advanced regression techniques in energy forecasting showcases the potential of modern data science methods in solving complex real-world problems, inspiring further research and innovation in energy analytics and beyond. By analysing regional differences in energy consumption patterns, the research can provide tailored recommendations for different areas within Malaysia, ensuring that energy policies and management strategies are effectively targeted to meet the specific needs of various regions and promote balanced regional development.

The study's scenario analysis component allows stakeholders to understand how different economic, environmental, and technological changes could impact future energy consumption. This proactive approach aids in developing resilient energy strategies capable of adapting to various potential futures. Additionally, the research contributes to building local expertise in energy forecasting and data analytics, enhancing the capabilities of Malaysian institutions and professionals in leveraging advanced analytical techniques for energy management and other applications.

While focused on Malaysia, the methodologies and findings of this research have broader implications. Other countries, particularly those in similar stages of development, can draw lessons from this study to improve their energy forecasting and management practices. This research provides critical insights and practical tools for improving energy management, supporting sustainable development, and enhancing Malaysia's economic and environmental well-being. Its significance extends beyond immediate applications, fostering innovation and capacity building that can benefit the energy sector and society.

1.7 Conclusion

This research on time series forecasting for energy consumption in Malaysia using regression techniques addresses the critical need for accurate and reliable energy consumption forecasts to support effective energy management and policymaking. The study aims to identify key influencing factors and provide precise predictions of future energy demand by analysing historical energy consumption data and employing various regression models. The research encompasses a comprehensive scope, including the collection and preprocessing of data, model development and validation, scenario analysis, and examining regional differences in energy consumption patterns. The findings will enhance Malaysia's energy security, economic efficiency, and environmental sustainability. Additionally, the study's insights will support policymakers in formulating strategies that promote the optimal use of energy resources and the integration of renewable energy sources. The significance of this research extends beyond Malaysia, offering valuable methodologies and lessons for other countries facing similar energy challenges. Ultimately, this research contributes to the sustainable development of Malaysia's energy sector, fostering innovation and capacity building in energy forecasting and management.