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Electricity Tariff Analysis and Prediction System Using the Arima Algorithm Based on the Internet of Things

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Abstract

The problem of monthly electricity bills in Indonesia is often a hot topic among the public. Some of the problems with electricity bills that are often complained about by the public include: The increase in basic electricity rates by the government or PLN (State Electricity Company) is often the main complaint. This increase can have a significant impact on people's monthly expenses. Many customers feel that their electricity bills do not match their actual usage. This can be caused by uncontrolled electricity usage or devices that consume more electricity than expected. There are cases where errors in electricity meter readings occur, either due to human error or damage to the meter. This error can result in electricity bills that are higher or lower than actual usage. Some customers feel they do not get clear information about the details of their bills. This lack of transparency can lead to distrust of PLN. Several additional costs such as administration fees, late payment fees, and other costs can add to the burden on monthly electricity bills. Based on the above problems, we built a Smart Precision Electric platform system based on IoT and Artificial Intelligence as a Predictive Model for Electricity Bills. The system we built is able to predict next month's electricity bill and identify the electronic devices that contribute the most to that cost using the integration of the Internet of Things Platform and Artificial Intelligence.

Keywords*:* Predictif Model, Internet of Things (IoT), Smart Precision Electric, Arima Algorithm

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INTRODUCTION

The issue of monthly electricity billing in Indonesia has consistently remained a contentious subject of public debate, primarily due to the socio-economic impact of fluctuating energy costs. A major source of frustration among citizens is the periodic adjustment of basic electricity rates by the government or the State Electricity Company (PLN), which often places a significant strain on household budgets. Many consumers find themselves struggling to reconcile their monthly earnings with these rising costs, leading to widespread complaints regarding the affordability of essential power services. This financial pressure is frequently exacerbated by a perceived lack of control over how these rates are determined and implemented across the diverse Indonesian archipelago[1].

Beyond the baseline rates, a pervasive problem lies in the discrepancy between perceived electricity usage and the final amount billed to the consumer. Many customers frequently encounter bills that seem disproportionately high compared to their daily habits, which is often a result of uncontrolled power consumption or the use of inefficient electronic devices that draw more energy than expected[2] . The billing process is sometimes marred by inaccuracies stemming from faulty electricity meters or human error during manual readings. These inconsistencies not only lead to financial disputes but also foster a deep-seated sense of distrust toward the utility provider, as customers feel they are being charged for energy they did not actually consume[3].

Transparency or the lack thereof serves as another critical hurdle in the current Indonesian energy landscape, as many consumers report receiving bills that lack detailed, understandable breakdowns. This opacity makes it difficult for households to identify which specific behaviors or appliances are driving their costs upward, leaving them powerless to implement effective energy-saving measures. Additionally, the inclusion of various supplementary charges, such as administrative fees and penalties for late payments, further complicates the billing structure. Without a clear and transparent accounting of these costs, the public's skepticism toward PLN continues to grow,

[1] Justin Luke and others, 'Optimal Coordination of Electric Buses and Battery Storage for Achieving a 24/7 Carbon-Free Electrified Fleet', *Applied Energy*, 377 (2025), doi:10.1016/j.apenergy.2024.124506; Kai Xue and others, 'Joint Dispatch and Economic Collaboration of Multiple Regional Energy Systems via Transformer-Based Load Prediction and Two-Stage Stochastic Optimization', *Energy*, 333 (2025), doi:10.1016/j.energy.2025.137321.

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highlighting a desperate need for a more modernized and communicative billing system [4].

To address these systemic challenges, the Smart Precision Electric platform was developed, integrating the Internet of Things (IoT) and Artificial Intelligence (AI) to serve as a robust Predictive Model for Electricity Bills [5]. This innovative system moves beyond traditional reactive billing by providing a proactive digital infrastructure that empowers users to monitor their consumption in real-time. By utilizing IoT-enabled sensors, the platform captures granular data on energy flow throughout a property, ensuring that the information used for billing is both accurate and verifiable. This technological intervention aims to eliminate the "black box" nature of utility costs, replacing ambiguity with data-driven clarity and precision [6].

At the heart of this platform is a sophisticated prediction and analysis engine built upon ARIMA (AutoRegressive Integrated Moving Average) machine learning. This system is specifically designed to forecast the following month's electricity bill with high accuracy, while simultaneously identifying the specific electronic devices that contribute most significantly to the overall expenditure. By merging the data-gathering capabilities of the IoT platform with the analytical power of AI, the system provides users with actionable insights into their energy habits. This allows consumers to not only anticipate their future financial obligations but also to strategically manage their device usage, ultimately promoting greater cost accuracy and financial transparency in the energy sector.

RESEARCH METHODS

1) Description of the Approach Used

The development approach for this predictive analysis platform utilizes Research and Development (R&D). Research is a method used to develop a specific product. To produce a specific product, research is needed, including needs analysis and testing the product's effectiveness to ensure its functionality in the wider community.

2) Method of collecting data

The approach used in developing this platform is a quantitative research method, which processes statistical data in the form of numbers. The application of quantitative

[4] Sri Jumiyati and Evi Frimawaty, 'The Development of an Edu-Agrotourism Concept in the Buffer Zone of Conservation Area Based on Education and Local Community Empowerment', *IOP Conference Series: Earth and Environmental Science*, 1275.1 (2023), doi:10.1088/1755-1315/1275/1/012027.

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methods to obtain data in this platform's development can be done objectively by building an Internet of Things platform to obtain measurable data on electricity usage.

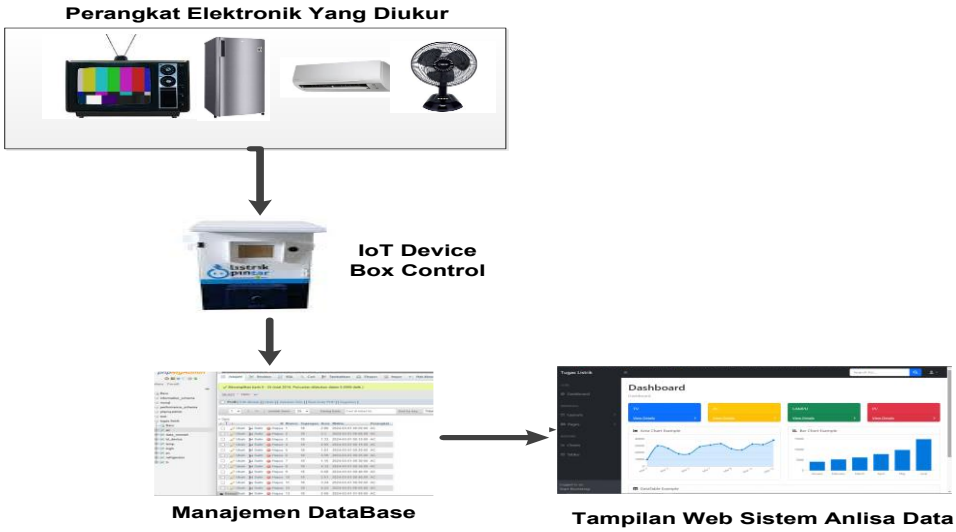


Figure 1.Internet of Things (IoT) Based Data Collection Method

In platform development, we created a dataset from sensors installed on electronic devices and integrated it into our Internet of Things platform. The dataset obtained from sensor readings was then processed into a dataset and visualized on a database management platform. At this stage, a predictive model was developed using machine learning and the ARIMA algorithm to estimate the monthly electricity bill and remaining balance, and to determine its contribution to costs.

3) Data Analysis Techniques

In developing this platform we use the ARIMA (Autoregressive Integrated Moving Average) data analysis method, a method based on historical variable value data which is then used to determine historical patterns in the data to extrapolate those patterns into the future. The ARIMA method we use is a combination of the Autoregressive Model (AR) and the Moving Average Model (MA) developed by Gwilym Jenkins and George Box.

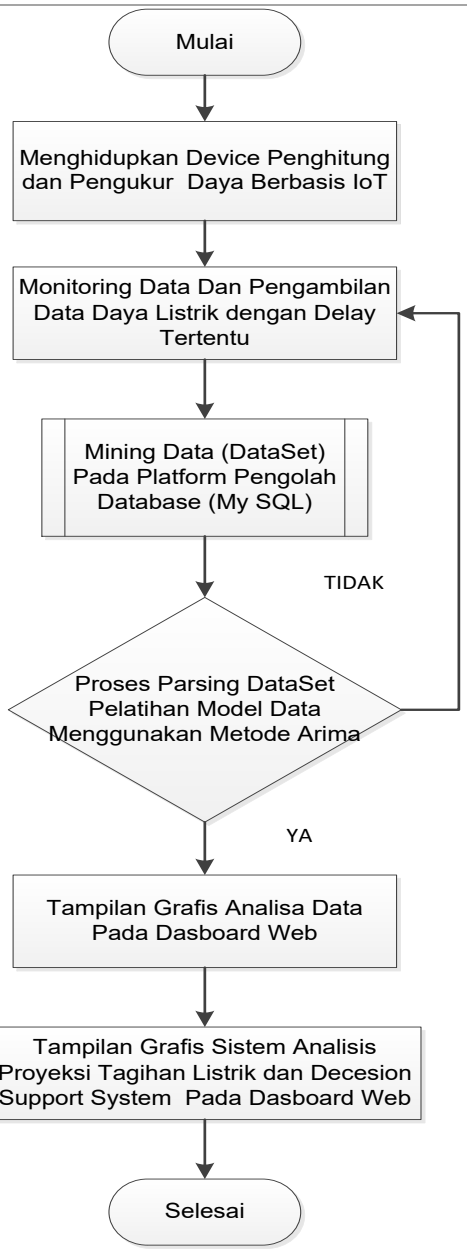


Figure 2 Data Analysis Flowchart

The stages above are the steps taken to produce the desired and maximum prediction and analysis system.

4) Decision Making System

A decision-making system is a series of processes and methodologies used to make the best choice among various available alternatives. The decision-making system in our electricity bill analysis prediction system helps in distribution planning and control of various electrical equipment activities. Our decision-making system functions in applications related to operational decisions regarding the use of electrical equipment in daily operations.

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RESULT AND DISCUSSION

a) Design System

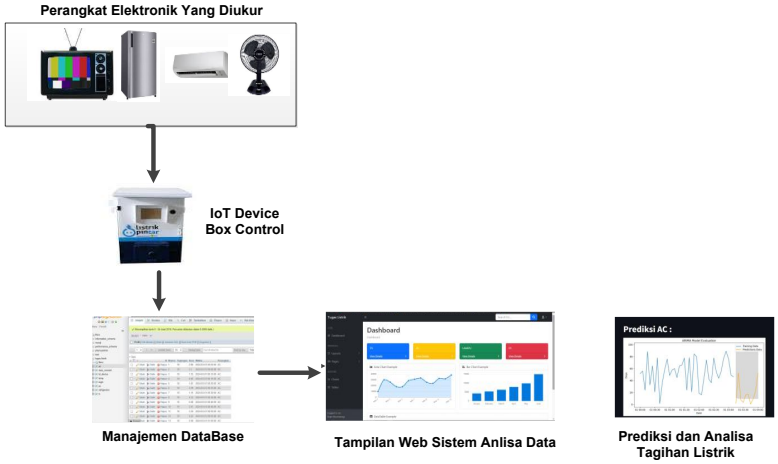


Figure 3 IoT Design System

The working principle of this research development is to create a data collection from sensors installed on electronic devices and integrated into the Internet of Things platform on the control box we built. The data collection obtained from sensor readings is then continued to the dataset process and data visualization on the database management platform. At this stage, the development is then carried out by parsing the data using a predictive model with machine learning modeling using the ARIMA algorithm to estimate the bill and remaining electricity bill for that month and contribute to the cost.

2) Power Sensor Device

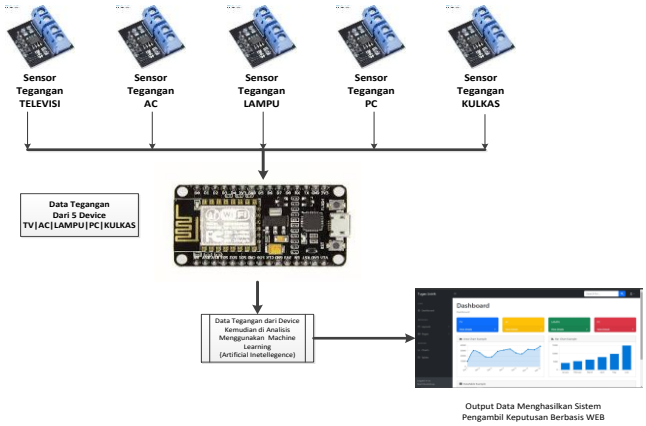


Figure 4 Sensor Device Circuit

This system utilizes real-time sensor data collected from various household appliances. This system generally aims to identify the power on certain electronic devices, for example TV, AC, Lights, PC, Refrigerator.

3) Data Preparation

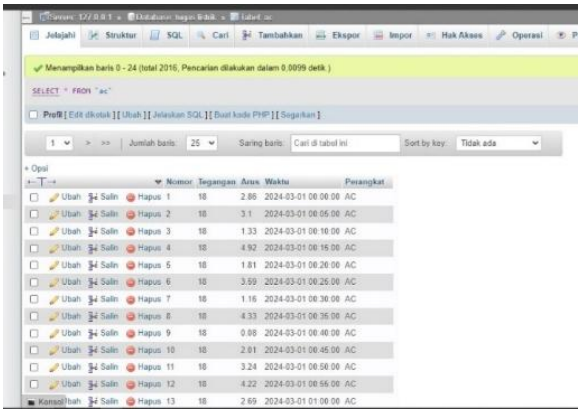


Figure 5 Data Preparation System

Explore data sets provided by Internet of Things (IoT) platforms and perform necessary data preprocessing steps to handle missing values or outliers.

4) Model Design

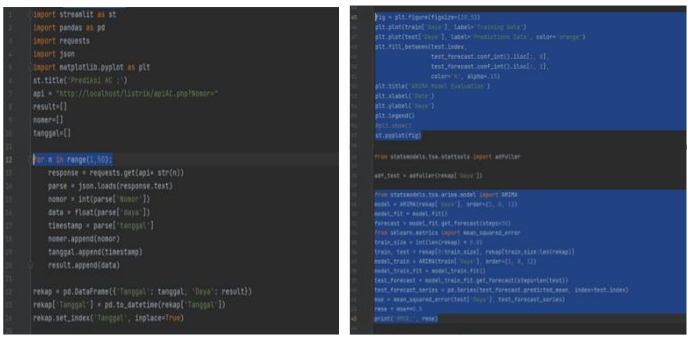


Figure 6 Design Using ARIMA Algorithm

Create a machine learning model based on the ARIMA algorithm to estimate the remaining electricity bill for the month and identify the device's contribution to the cost.Using an appropriate algorithm with detailed prediction and analysis capabilities, in this case, the ARIMA Algorithm Method.

5) Model Evaluation and Training

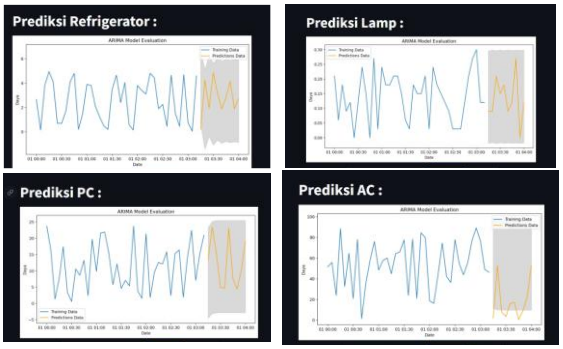


Figure 7 Model Evaluation and Training

Train the model based on historical data and evaluate its performance using relevant metrics. This stage involves identifying and converting ARIMA algorithm calculations using the Python programming language.

The comprehensive discussion of the Smart Precision Electric platform begins with the Design System, which establishes the foundational workflow for data integration and predictive analysis. The core working principle involves a continuous cycle of data collection from specialized sensors installed directly onto various electronic devices. These sensors are integrated into a centralized Internet of Things (IoT) control box, which serves as the primary gateway for transmitting raw electrical data. Once captured, this information is processed through a dataset pipeline and presented via a database management platform for real-time visualization, allowing for a seamless transition from hardware sensing to digital interpretation [7].

To ensure the system captures granular usage patterns, the Power Sensor Device is strategically deployed to monitor specific household appliances with high energy demands. This hardware layer is designed to identify the real-time power consumption of devices such as air conditioners, televisions, refrigerators, personal computers, and lighting systems. By isolating the power signatures of individual appliances, the system creates a high-fidelity map of energy flow, which is essential for the subsequent stages of identifying which specific devices are the primary contributors to the monthly financial burden [8].

Before any predictive modeling can occur, a rigorous Data Preparation phase is executed to ensure the integrity of the information retrieved from the IoT platform. This stage involves deep exploration of the datasets to identify and rectify potential anomalies, such as missing values or outliers that could arise from sensor interruptions or electrical surges [9]. By performing these preprocessing steps, the system ensures that the input data is clean and consistent, which is a critical prerequisite for achieving high accuracy in the machine learning phase and avoiding skewed results in the final bill estimation.

The intelligence of the platform is centered on the Model Design, which utilizes the ARIMA (AutoRegressive Integrated Moving Average) Algorithm to handle the complexities of electricity consumption patterns. This specific algorithm was selected for its superior ability to analyze time-series data that is non-stationary and seasonal [10]. By

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applying the ARIMA method, the system can meticulously estimate the remaining electricity bill for the current month while simultaneously calculating the exact cost contribution of each monitored device. This detailed analysis transforms raw consumption numbers into actionable financial insights for the user.

The Model Evaluation and Training phase ensures the reliability and precision of the generated forecasts. The model is trained using historical consumption data, allowing the algorithm to "learn" the unique usage habits of the household or facility. This process involves converting complex ARIMA mathematical calculations into functional scripts using the Python programming language. Performance is then scrutinized using relevant evaluation metrics to confirm that the predictions align closely with actual usage. This iterative training ensures that the Smart Precision Electric platform remains an accurate and trustworthy tool for proactive operational cost management.

CONCLUSION

The developed Smart Precision Electric platform successfully establishes a robust integration of Internet of Things (IoT) devices, enabling the seamless collection of real-time electricity consumption data and historical tariff patterns. By utilizing the ARIMA (AutoRegressive Integrated Moving Average) algorithm, the system effectively analyzes complex time-series data characterized by non-stationary, seasonal, and autocorrelated consumption behaviors. This integration provides a comprehensive solution that not only presents analyzed consumption metrics but also delivers accurate predictive information regarding future electricity costs, allowing for a higher level of financial transparency and accuracy in billing.

The practical implementation of this system offers significant added value for both individual and corporate users by facilitating data-driven decision-making regarding energy efficiency. By providing insights into next month's predicted costs and identifying the specific electronic devices that contribute most to expenditure, the platform allows for strategic scheduling of electrical equipment usage. This proactive approach to operational cost management empowers users to control their energy habits more effectively, ultimately addressing long-standing public concerns regarding bill discrepancies and unexpected price hikes.

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