Computer Engineering and Applications Vol. 13, No. 2, June 2024

Electrical Energy Monitoring and Analysis System At Home Using Iot-Based Prophet Algorithm

Vipkas Al Hadid Firdaus[1], Meyti Eka Apriyani[2]. Nurus Laily Aprilia[3]

[1,2,3]*Department of Information Technology, Politeknik Negeri Malang*
[1]*vipkas@polinema.ac.id*, [2]*meytieka@polinema.ac.id*, [3]*nuruslaily88@gmail.com*

ABSTRACT

Electrical energy is one of the necessities of human life, especially in modern society in urban areas. With a monitoring device for electrical energy consumption using IoT technology, the results of the development show that the monitoring system works well, but the results show that current and voltage measurements are still less accurate. Therefore, in this study, an Electrical Energy Analysis and Monitoring System were developed using the IoT-Based Prophet Algorithm. Data collection was obtained from electrical energy using the PZEM-004T module sensor device used at home and the energy data obtained were stored in a MySQL database. This PZEM data retrieval will appear in real time on the Monitoring Website. The dataset was processed by implementing the Prophet Algorithm, evaluating the model and visualizing the prediction results on the analysis website. Testing using Mean Absolute Percentage Error (MAPE). For design, this system uses energy data and data retrieval time as parameters in the monitoring system for the use of electrical energy at home. Analysis of data taken from electrical energy monitoring was predicted by the model created by the Prophet Algorithm and tested with MAPE to see how accurate the predicted value is in the Prophet Algorithm model. Predictions in this study get an error value of less than 10%, namely 6.87%, which means it is very accurate in predicting the prophet algorithm at home.

Keywords: PZEM, the Prophet Algorithm, Prediction, MAPE, Home.

1. INTRODUCTION

Technology is currently growing very rapidly [1]. Even at every second, humans have utilized various kinds of technology in their activities [2], for example, the application of Internet of Things technology. One of the uses of the Internet of Things is the use of electrical energy[3]. Electrical energy is one of the necessities of human life, especially in modern society in urban areas. All kinds of equipment, from home appliances to modern equipment in industry and offices all use electrical energy to run it. Electrical energy consumption in Indonesia in recent years has increased by 10 to 15% per year.

By developing a monitoring device for electrical energy consumption using IoT technology, the results of the development show that the monitoring system has worked well, but the measurement results show that current and voltage measurements are still less accurate, because the reading power is quite different from the load power. Therefore, in this study, an IoT-based electrical energy monitoring system will be developed.

By using a website that is connected to IoT device connectivity and using the MQTT protocol. The device used is the PZEM-004T Arduino Electrical monitoring KWH Watt Meter. The data released from the device can be seen through the monitoring website. In addition to monitoring, it can also analyze energy to find out predictions of electrical energy used by using the Prophet Algorithm. With predictions that provide historical data to forecast with the Prophet's Algorithm model and add optional data that can affect forecasts. Forecast will be used to analyze time-series trend patterns that increase, decrease or remain in the long term (trend) [4]. This algorithm works very well using time series data with strong seasonal effects and data sets with a lot of data.

2. METHODS

2.1 TIME AND PLACE RESEARCH

The research was conducted on houses for 6 months starting from February 2022 to July 2022.

2.2 DATA COLLECTION TECHNIQUES

Testing data collection is obtained from electrical energy using the PZEM-004T module sensor device used in the house and the energy data obtained will be stored in a MySQL database. This PZEM data retrieval will appear in real-time on the Monitoring Website.

2.3 DATA PROCESSING TECHNIQUES

The dataset is processed through several stages, namely: data filling, data preprocessing, dataset collection, data transformation, Prophet Algorithm implementation, model evaluation and visualization of prediction results on monitoring websites.

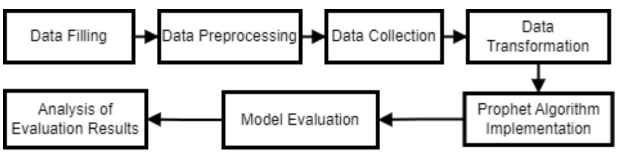


FIGURE 1. Processing Flowchart

1. Data Filling is an activity to fill in data that is lost, damaged or not in the proper format [5].
2. Data Preprocessing is the process of preparing data to be entered into the model [6].
3. Dataset collection is a process for collecting data in the form of training data and testing data [7].

ISSN: 2252-4274 (Print)
ISSN: 2252-5459 (Online)

4. Data Transformation is a process for splitting data into training data and test data, which is carried out to find out how accurate the prediction results are through the model made on the predicted energy consumption data [8].
5. Implementation of the Prophet's Algorithm to predict energy consumption implemented using the fbprophet library in Python programming language[9].
6. Model evaluation aims to measure the error value or accuracy of the prediction model built by comparing training data and testing data.

2.4 SYSTEM DESIGN

2.4.1 SOFTWARE DEVELOPMENT METHOD

In software development, the application of the Prophet's Algorithm on the Electrical Energy Analysis and Monitoring System in IoT-Based Homes uses the RAD Model Software Development Life Cycle (SDLC) flow. The following are the stages of the RAD model:

1. Requirements Planning

   The first step in this research is to collect the data needed for this research.

2. User Design (Creating a Prototype)

   The next stage is to make a prototype, sometimes it is also necessary to test it to reduce errors and debugging. Through this stage, there is capital to create an application that is easy to use, stable, does not often error and has the right design.

3. Construction (Coding Process)

   The next stage is construction in the form of implementing a programming language that is understood by the system based on the design that has been made.

4. Cutover (Implementation and Finalization)

   In the last step it is necessary to add to the shortcomings that may occur during the application development process. This task includes optimizing for application stability, improving the interface, performing maintenance and compiling documentation.

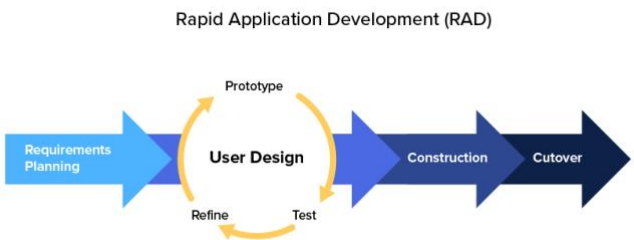


FIGURE 2. SDLC RAD **[10]**

2.4.2 SYSTEM ARCHITECTURE

The following is the architecture of the system that the researcher will make**:**

ISSN: 2252-4274 (Print)
ISSN: 2252-5459 (Online)

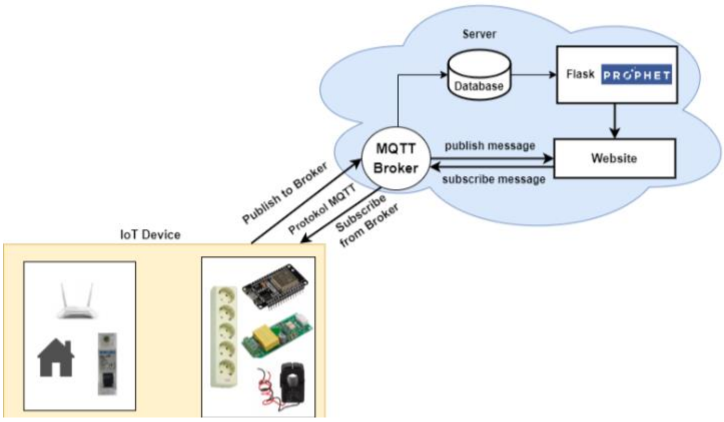


FIGURE 3. System Architecture

2.5 DESIGN

2.5.1 SYSTEM FLOWCHART

The system process to be created is explained through the following flowchart:

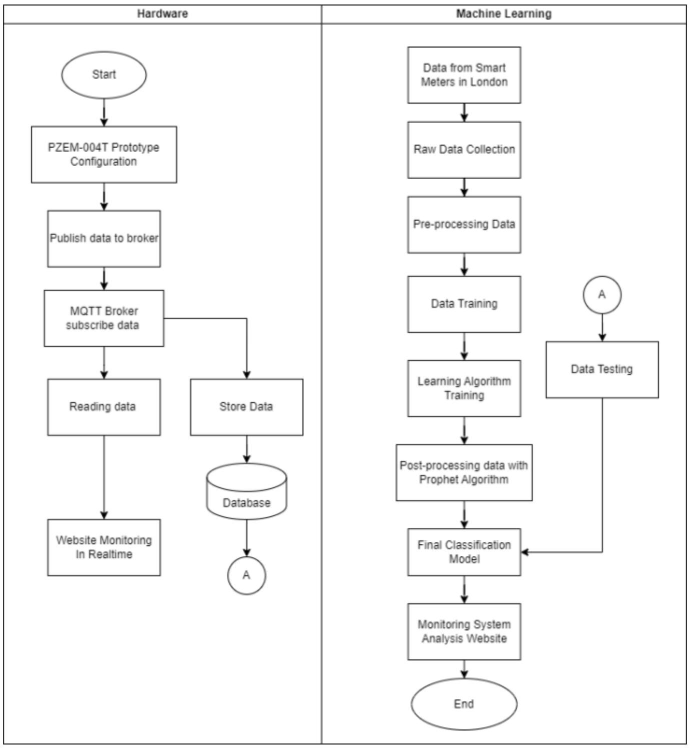


FIGURE 4. System Flowchart

2.5.2 FLOWCHART CALCULATION METHOD

The method flowchart is a sequence of work processes for the implementation of the calculation method, where in energy analysis the Prophet Algorithm or Facebook Prophet Model (FPM) method is used.

ISSN: 2252-4274 (Print)
ISSN: 2252-5459 (Online)

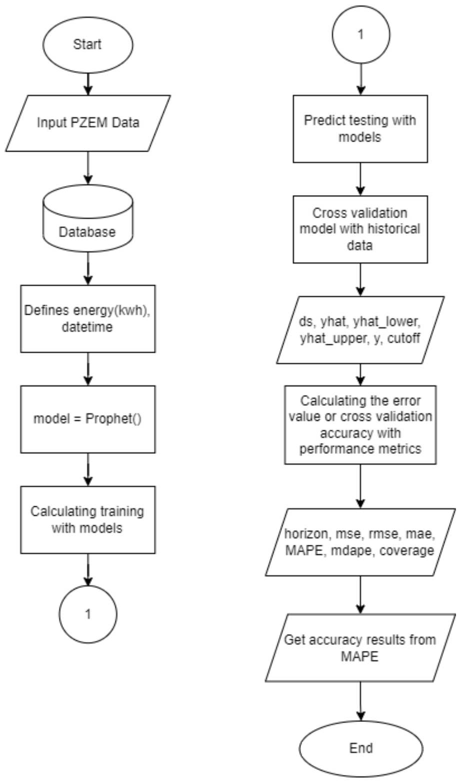


FIGURE 5. Flowchart Calculation Method

2.5.3 PROTOTYPE DESIGN

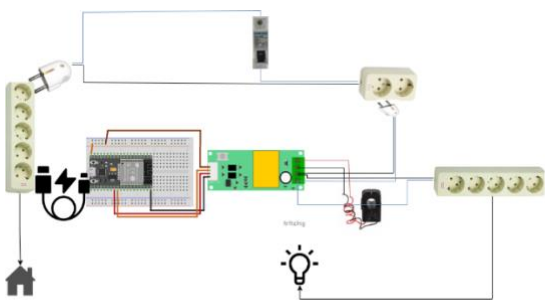


FIGURE 6. Prototype Design

The method flowchart is a sequence of work processes for the implementation of the calculation method, where in energy analysis the Prophet Algorithm or Facebook Prophet Model (FPM) method is used.

2.5.4 BLOCK DIAGRAM

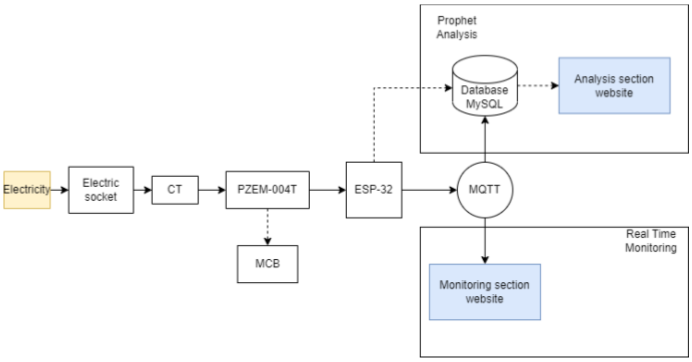


FIGURE 7. Block Diagram

2.5.5 USE CASE DIAGRAM

Use case diagram is a structure that describes the relationship that occurs between actors and the activities carried out [11]. The use case diagram for the Electrical Energy Analysis and Monitoring System in an IoT-Based Home can be seen in the following figure:

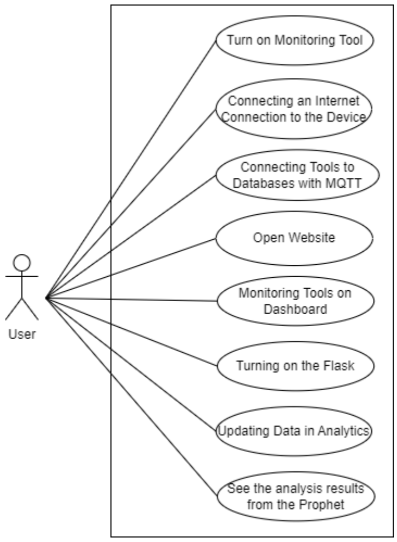


FIGURE 8. Use case Diagram of Monitoring and Analysis System

The picture above is a common activity that occurs when users perform PZEM Monitoring and Prophet Analysis. The activity in the activity diagram begins when the user first turns on the PZEM sensor module monitoring tool and connects to an internet connection. Then the tool will be connected to the installed database, the obtained PZEM data will be saved to the database using the MQTT protocol.

Users can then open the website and see the initial display, namely a dashboard that displays real time monitoring of the PZEM sensor module. The display is in the form of Energy and Current graphs and a table of all monitored data from PZEM in

ISSN: 2252-4274 (Print)
ISSN: 2252-5459 (Online)

the form of time, Energy, Power, Current, Frequency, Voltage and Power Factor (PF) data. The user can then fire up Flask to calculate the Prophet's Algorithm. In the analytic display, users need to press the 'Update Data' button and will see the results of the Prophet's Algorithm calculation analysis.

2.5.6 ACTIVITY DIAGRAM

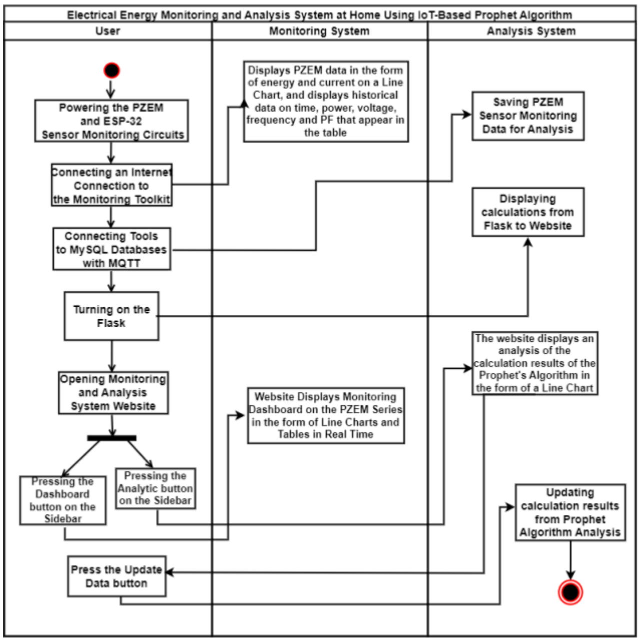


FIGURE 9. Activity Diagram of Monitoring and Analysis System

3. RESULT AND DISCUSSION

3.1 IMPLEMENTATION HARDWARE

3.1.1 PROTOTYPE

The prototype is used to simulate the monitoring of Electrical Energy used at home. In addition to Energy output, this prototype is also equipped with Voltage, Current, Power, Frequency and PF (Power Factor) monitoring.

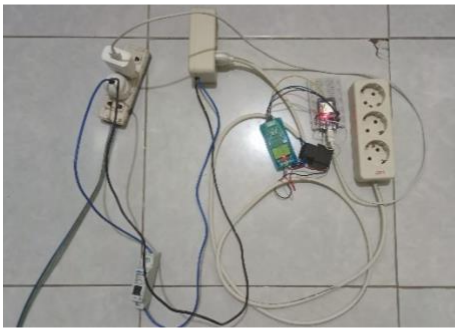


FIGURE 10. Prototype Making

3.1.2 EMBEDDED SYSTEM

Embedded systems include ESP32, PZEM-004T, Open-Close CT, MCB modules and sockets to enter the load using electrical power.

FIGURE 11. Circuit connected with MCB

The series of monitoring system devices are connected by cables that are directly connected to the house electricity.
To inhibit the short current in PZEM, a 2 Ampere MCB device is added, so that if it causes a short circuit, it will turn off the MCB.

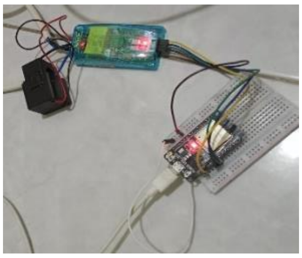


FIGURE 12. PZEM circuit with CT connected ESP32

The PZEM circuit is connected to the ESP-32 and to inhibit high currents, here using an Open-Close CT which is used in the cable connected to the wall outlet, the load is used to use electrical power.

3.2 IMPLEMENTATION OF THE PROPHET ALGORITHM METHOD

The implementation of the Prophet's Algorithm method is carried out on Flask Python by retrieving the data stored in the database and connecting it to the monitoring and analysis system. The data used is daily data on electrical energy consumption carried out at home from 12 June 2022 to 12 July 2022.

ISSN: 2252-4274 (Print)
ISSN: 2252-5459 (Online)

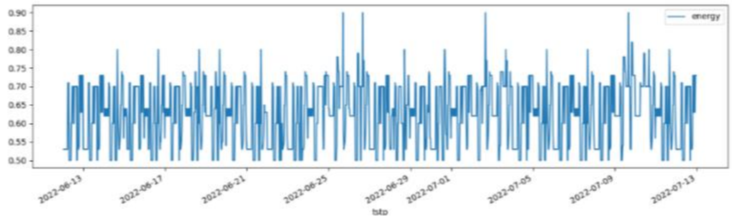


FIGURE 13. Energy Consumption Data at Home

The Prophet's algorithm requires 2 input dataframes in the form of "tstp" namely datetime, and "y" the value you want to predict, namely energy.

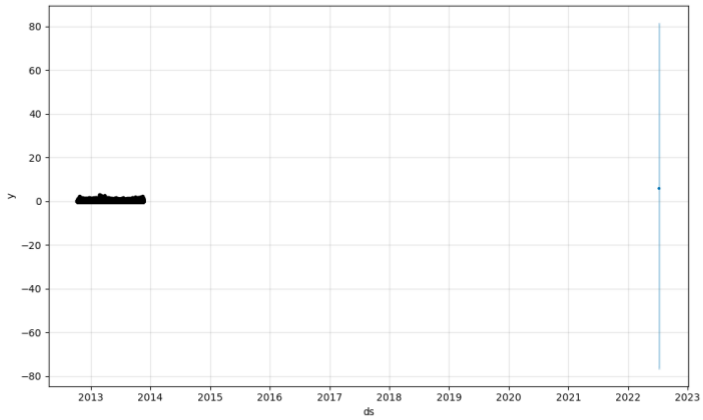


FIGURE 14**.** Forecast Plot Energy

In Figure 5.5, the dark blue dot is the value of the predicted energy “yhat”, the black dots that gather are the actual value of energy “y”. The light blue color represents the intervals around the prediction. The uncertainty intervals around this area are limited by the predicted “yhat_lower” and “yhat_upper” predicted values.

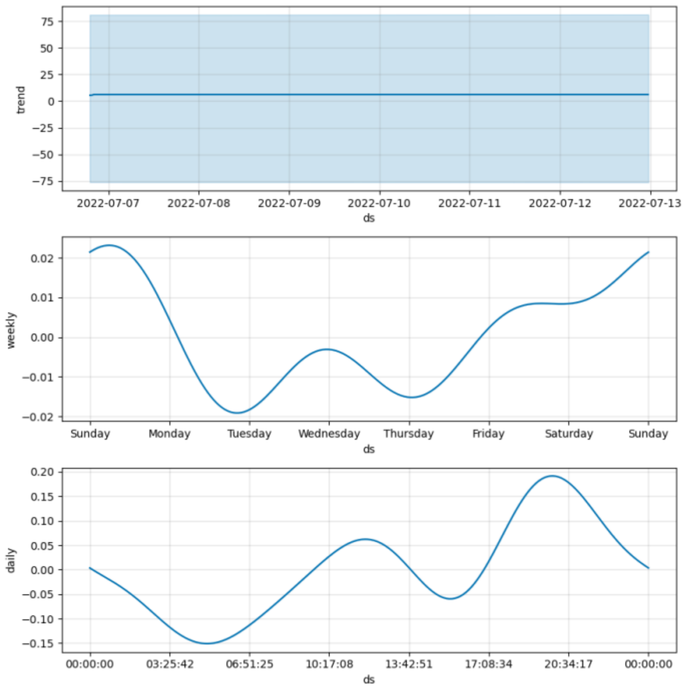


FIGURE 15. Components Plot Energy

It can be observed that the plot of the forecast component is shown in Figure 5.6 where there are trends, weekly, and daily. The trend component seems to be pointing up. The weekly seasonality component shows that the energy used on weekends is increasing, and decreases from Monday to Friday. This may indicate a holiday effect (holiday). The daily seasonality component shows that the energy used increases at certain hours, especially at night.

	ds	yhat	yhat_lower	yhat_upper	y	cutoff
0	2012-10-19 10:00:00	0.358224	0.146628	0.557347	0.083	2012-10-19 09:30:00
1	2012-10-19 10:30:00	0.386579	0.185458	0.600848	0.119	2012-10-19 09:30:00
2	2012-10-19 11:00:00	0.401921	0.183670	0.600750	0.095	2012-10-19 09:30:00
3	2012-10-19 11:30:00	0.400903	0.182327	0.607872	0.105	2012-10-19 09:30:00
4	2012-10-19 12:00:00	0.382599	0.175392	0.596813	0.108	2012-10-19 09:30:00

FIGURE 16. Cross Validation Energy

The Prophet's algorithm applies the Cross Validation function or time series cross validation to measure the forecast error by comparing the predicted value with the actual value. To implement the cross_validation function, we need the horizon parameter, and additional parameters such as initial, period and other parameters. But it can also be only with horizon. And in Figure 5.7 is a cross validation of the energy consumed at home.

ISSN: 2252-4274 (Print)
ISSN: 2252-5459 (Online)

TABLE 1.

Performance Metric

Horizon	Mse	Rmse	Mae	Mape	Mdape	Coverage
0 days 02:30:00	0.06	0.24	0.15	0.69	0.46	0.8772
0 days 03:00:00	0.05	0.23	0.15	0.67	0.42	0.8822
0 days 03:30:00	0.05	0.22	0.14	0.66	0.41	0.8866
0 days 04:00:00	0.04	0.21	0.13	0.64	0.4	0.8945
0 days 04:30:00	0.04	0.2	0.12	0.62	0.41	0.9001
0 days 05:00:00	0.04	0.19	0.12	0.6	0.42	0.9081
0 days 05:30:00	0.03	0.17	0.11	0.58	0.42	0.9219
0 days 06:00:00	0.03	0.16	0.1	0.56	0.42	0.9353
0 days 06:30:00	0.02	0.15	0.09	0.55	0.43	0.944
0 days 07:00:00	0.02	0.15	0.09	0.56	0.43	0.9519
0 days 07:30:00	0.02	0.15	0.09	0.59	0.46	0.955
0 days 08:00:00	0.02	0.15	0.09	0.62	0.49	0.9512
0 days 08:30:00	0.02	0.16	0.1	0.66	0.52	0.9445
0 days 09:00:00	0.03	0.17	0.11	0.69	0.55	0.933
0 days 09:30:00	0.04	0.21	0.13	0.72	0.56	0.8946
0 days 10:00:00	0.05	0.23	0.15	0.74	0.57	0.869
0 days 10:30:00	0.07	0.26	0.17	0.76	0.57	0.8329
0 days 11:00:00	0.08	0.28	0.18	0.78	0.59	0.801
0 days 11:30:00	0.08	0.28	0.19	0.8	0.6	0.7872
0 days 12:00:00	0.07	0.27	0.19	0.8	0.61	0.7987
0 days 12:30:00	0.07	0.26	0.19	0.79	0.6	0.8077
0 days 13:00:00	0.06	0.25	0.18	0.77	0.59	0.8285

0 days 13:30:00	0.06	0.25	0.17	0.74	0.54	0.848
0 days 14:00:00	0.06	0.24	0.16	0.72	0.5	0.8619
0 days 14:30:00	0.06	0.24	0.15	0.69	0.47	0.8738
0 days 15:00:00	0.05	0.23	0.15	0.68	0.43	0.879
0 days 15:30:00	0.05	0.22	0.14	0.66	0.41	0.8853
0 days 16:00:00	0.04	0.21	0.13	0.64	0.41	0.8938
0 days 16:30:00	0.04	0.2	0.12	0.62	0.42	0.8992
0 days 17:00:00	0.04	0.19	0.12	0.61	0.43	0.9059
0 days 17:30:00	0.03	0.18	0.11	0.59	0.43	0.9191
0 days 18:00:00	0.03	0.16	0.1	0.57	0.43	0.9315
0 days 18:30:00	0.02	0.16	0.09	0.56	0.44	0.9385
0 days 19:00:00	0.02	0.15	0.09	0.57	0.44	0.9463
0 days 19:30:00	0.02	0.15	0.09	0.6	0.46	0.9494
0 days 20:00:00	0.02	0.15	0.1	0.63	0.49	0.9455
0 days 20:30:00	0.03	0.16	0.1	0.66	0.52	0.9386
0 days 21:00:00	0.03	0.17	0.11	0.7	0.55	0.9271
0 days 21:30:00	0.05	0.21	0.14	0.72	0.56	0.8888
0 days 22:00:00	0.05	0.23	0.15	0.74	0.56	0.865
0 days 22:30:00	0.07	0.26	0.17	0.77	0.57	0.83
0 days 23:00:00	0.08	0.28	0.19	0.79	0.58	0.7982
0 days 23:30:00	0.08	0.28	0.19	0.81	0.6	0.7869
1 days 00:00:00	0.07	0.27	0.19	0.81	0.61	0.797

The Prophet Algorithm also provides performance_metric to measure the error value. And seen on MAPE, an error value of around 0.68 is typical for predictions over the next 1 day, and that error increases to around 0.80 for predictions that come out for 1 day.

ISSN: 2252-4274 (Print)
ISSN: 2252-5459 (Online)

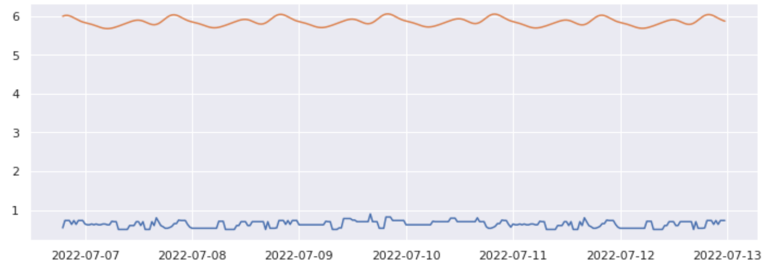


FIGURE 17. Plot Actual Value with Predicted Value

Figure 5.16 shows a plot of the actual value with the predicted value. The blue color is the actual value while the orange color is the prophet's prediction value.

3.3 DISCUSSION

3.3.1 DISCUSSION OF PZEM TEST RESULTS ON THE SYSTEM

The results of the PZEM test on the system are carried out by turning on the PZEM monitoring tool and connecting it to a home power source to see changes in energy, voltage, current, power, frequency and power factor (PF) with time per second but displayed within a certain period of time.

TABLE 2.
Discussion of PZEM Sensor Test Results

Datetime	Reading PZEM					
	Energy	Power	Voltage	Current	Frequency	PF
14/7/2022 21.03.37	0.07	17.4	231.6	0.15	50	0.51
14/7/2022 21.03.50	0.07	17.6	231.9	0.15	50	0.51
14/7/2022 21.03.53	0.07	17.6	231.2	0.15	50	0.51
14/7/2022 21.03.56	0.07	16.8	231.4	0.14	50	0.51

3.3.2 DISCUSSION OF PZEM SENSOR MODULE CALIBRATION TEST RESULTS

The results of the PZEM sensor module calibration test is carried out by turning on the PZEM monitoring tool and using the sensor calibration tool, namely the avometer/multimeter, which the avo/multimeter can read current and voltage.

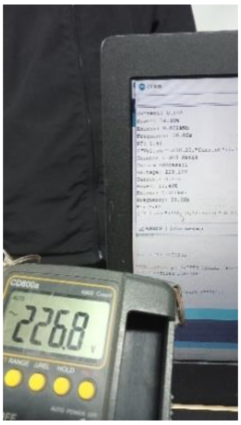


FIGURE 18. Calibration with avometer

Seen in Figure 6.1, it can be seen that the output voltage on the Arduino microcontroller serial monitor is 228.1 v and the output on the Avometer is 226.8 v. This accuracy test is only a comparison difference of about 1v.

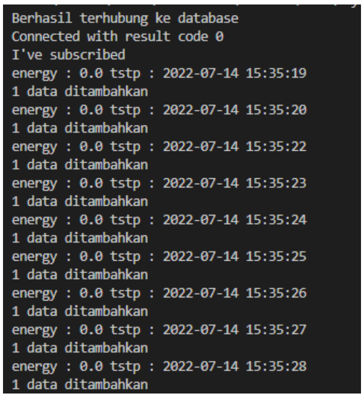
FIGURE 19. Calibration with clamp meter

Seen in Figure 6.2, it can be seen that the current that comes out on the Arduino microcontroller serial monitor is 0.23 A and that comes out on the clampmeter is 0.13 A. In this accuracy test, there is a 0.1A difference in comparison.

3.3.3 DISCUSSION OF THE TEST RESULTS OF SUBSCRIBE DATA AND INSERT DATABASE

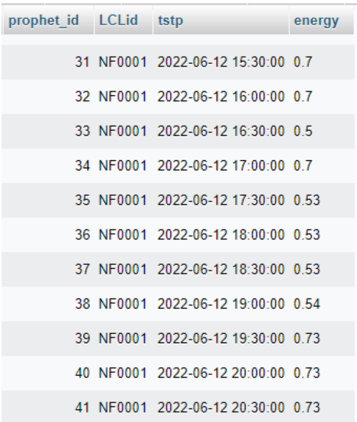
During the test, the system succeeded in subscribing to MQTT Broker by retrieving data from the ESP-32 Microcontroller and successfully inserting the id, energy and time data from the PZEM readings into the MySQL database. This is a basic function that must run because the data will be used in the calculation of the Prophet's Algorithm analysis.

ISSN: 2252-4274 (Print)
ISSN: 2252-5459 (Online)



```
Berhasil terhubung ke database
Connected with result code 0
I've subscribed
energy : 0.0 tstp : 2022-07-14 15:35:19
1 data ditambahkan
energy : 0.0 tstp : 2022-07-14 15:35:20
1 data ditambahkan
energy : 0.0 tstp : 2022-07-14 15:35:22
1 data ditambahkan
energy : 0.0 tstp : 2022-07-14 15:35:23
1 data ditambahkan
energy : 0.0 tstp : 2022-07-14 15:35:24
1 data ditambahkan
energy : 0.0 tstp : 2022-07-14 15:35:25
1 data ditambahkan
energy : 0.0 tstp : 2022-07-14 15:35:26
1 data ditambahkan
energy : 0.0 tstp : 2022-07-14 15:35:27
1 data ditambahkan
energy : 0.0 tstp : 2022-07-14 15:35:28
1 data ditambahkan
```

FIGURE 20. Discussion of the Subscription Data Test Results



prophet_id	LCLid	tstp	energy
31	NF0001	2022-06-12 15:30:00	0.7
32	NF0001	2022-06-12 16:00:00	0.7
33	NF0001	2022-06-12 16:30:00	0.5
34	NF0001	2022-06-12 17:00:00	0.7
35	NF0001	2022-06-12 17:30:00	0.53
36	NF0001	2022-06-12 18:00:00	0.53
37	NF0001	2022-06-12 18:30:00	0.53
38	NF0001	2022-06-12 19:00:00	0.54
39	NF0001	2022-06-12 19:30:00	0.73
40	NF0001	2022-06-12 20:00:00	0.73
41	NF0001	2022-06-12 20:30:00	0.73

FIGURE 21. Discussion of Insert Database Test Results

3.3.4 DISCUSSION OF WEBSITE MONITORING AND ANALYSIS TEST RESULTS

Based on the planning and testing that has been done, the main function of the monitoring and analysis website is to display information on all incoming data in real time from the PZEM monitoring tool and the energy data obtained from the PZEM is analyzed by the Prophet Algorithm. The data entered in the monitoring includes data on energy, voltage, current, power, frequency and power factor (PF) equipped with ID and time data. In addition to monitoring, the website also functions as a display of the results of the Prophet Algorithm analysis that has been run through Flask Python by presenting data in the form of a line chart.

ISSN: 2252-4274 (Print)
ISSN: 2252-5459 (Online)

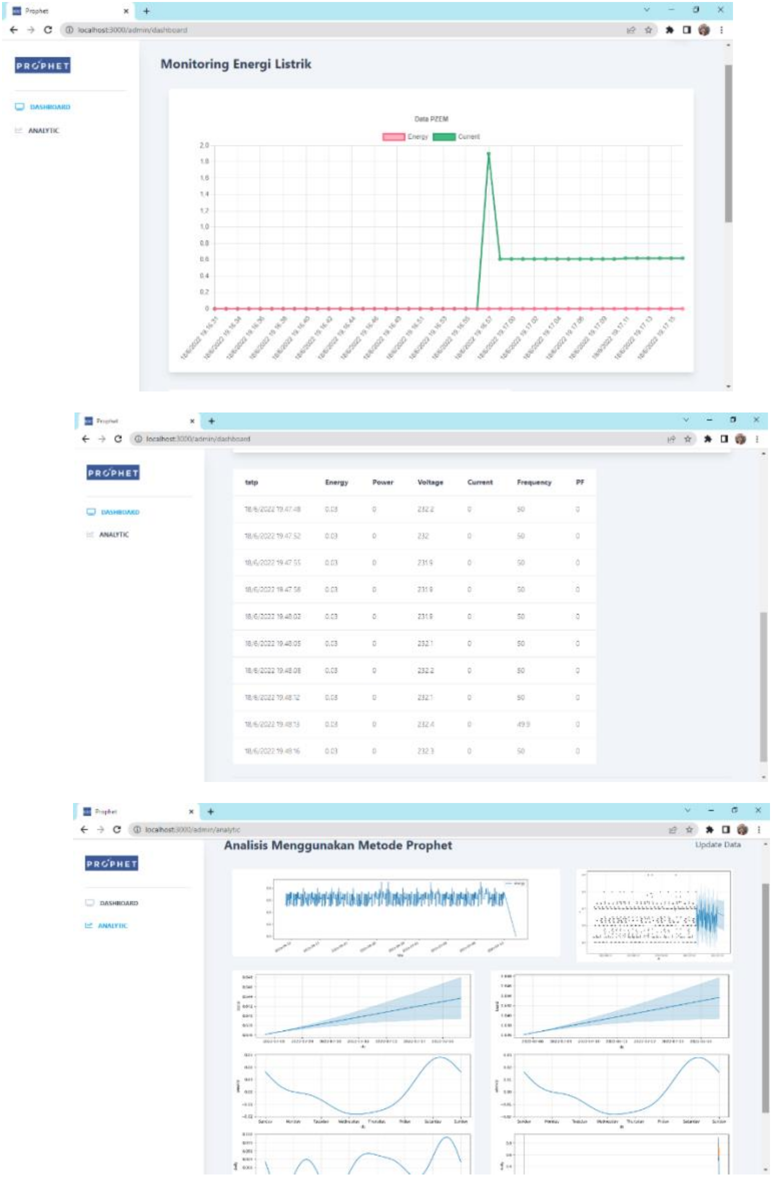


FIGURE 22. Discussion of Website Monitoring and Analysis Test Results

Access the website using localhost with the address http://localhost:3000/admin by first turning on xampp as a local server and running Flask python by flask run as a backend for prophet calculation analysis.

3.3.5 DISCUSSION OF THE TEST RESULTS OF THE PROPHET ALGORITMA ALGORITHM METHOD

This test is intended to find out how accurate the Prophet's Algorithm method has been implemented into a system. To measure the error value or accuracy of the predicted model, it will be built by comparing the test and training data that have been determined previously. The prophet model has provided the fbprophet library which has performance_metrics that can be used to calculate some useful predictive

ISSN: 2252-4274 (Print)
ISSN: 2252-5459 (Online)

performance statistics (yhat, yhat_lower, and yhat_upper compared to y), as a function of the cutoff distance (how far it is estimated). The statistics calculated are mean squared error (MSE), root mean squared error (RMSE), mean absolute error (MAE), mean absolute percent error (MAPE), median absolute percent error (MDAPE) and estimated range (coverage) yhat_lower and yhat_upper . But in this test using Mean Absolute Percentage Error (MAPE). The results of this test can describe how accurate the results of predictions made by models using training data are based on test data for comparison of predicted values.

TABLE 3.

Performance Metric

Horizon	Mse	Rmse	Mae	Mape	Mdape	Coverage
0 days 02:30:00	0.06	0.24	0.15	0.69	0.46	0.8772
1 days 00:00:00	0.07	0.27	0.19	0.81	0.61	0.797

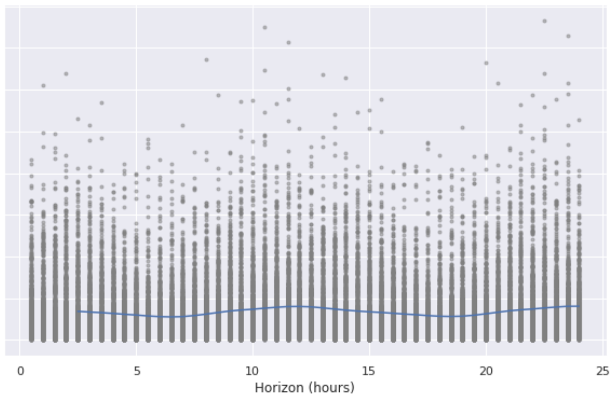


FIGURE 23. Plot Cross Validation MAPE

Seen in MAPE, an error value of about 6.87% is typical for predictions over the next 1 day, and that error increases to around 8.09% for predictions that are out for 1 day. MAPE criteria if the value is <10% then Very Accurate.

4. CONCLUSION

Based on research conducted on Electrical Energy Analysis and Monitoring Systems at Homes Using the IoT-Based Prophet Algorithm, the following conclusions can be drawn:

1. Design of Electrical Energy Analysis and Monitoring Systems at Homes Using the IoT-Based Prophet Algorithm with energy data and the time of data collection

can be used as parameters in the monitoring system for electrical energy use at home. For design, this prototype uses several components such as the ESP-32, the PZEM sensor module which is equipped with an integrated voltage sensor and current sensor (CT), a power outlet and added with MCB components so that there is no short circuit in the house. And has been tested for calibration with a multimeter / Avometer. Based on the test results, the tool that has been designed and calibrated gets a success percentage of 90% because the results shown are only 1V/0.1A difference. The design can monitor through the website of the Electrical Energy Analysis and Monitoring System at Home Using the IoT-Based Prophet Algorithm. The data exchange process that occurs within the entire system uses the MQTT protocol.

2. Analysis of the Prophet's Algorithm with data taken from electrical energy monitoring in the form of energy data and data retrieval time stored in the MySQL database. From the results of the Mean Absolute Percentage Error (MAPE) test, the predictions made by the Prophet Algorithm when viewed on the MAPE assessment criteria with conditions <10% then the value is very accurate. Predictions in this study get an error value of less than 10%, namely 6.87%, which means it is very accurate in predicting the prophet algorithm at home.

REFERENCES

[1] A. Bindra, “Utilizing Energy Harvesting to Power IoT Devices [From the Editor],” *IEEE Power Electron. Mag.*, vol. 8, no. 3, pp. 4–6, 2021, doi: 10.1109/mpel.2021.3099911.

[2] L. Minh Dang, K. Min, H. Wang, M. Jalil Piran, C. Hee Lee, and H. Moon, “Sensor-based and vision-based human activity recognition: A comprehensive survey,” *Pattern Recognit.*, vol. 108, p. 107561, 2020, doi: 10.1016/j.patcog.2020.107561.

[3] N. A. Hussien, A. A. D. Al Magsoosi, A. A. D. Al Magsoosi, H. T. Salim AlRikabi, and F. T. Abed, “Monitoring the Consumption of Electrical Energy Based on the Internet of Things Applications,” *Int. J. Interact. Mob. Technol.*, vol. 15, no. 7, pp. 17–29, 2021, doi: 10.3991/ijim.v15i07.20183.

[4] S. J. Taylor and B. Letham, “Forecasting at Scale,” *Am. Stat.*, vol. 72, no. 1, pp. 37–45, 2018, doi: 10.1080/00031305.2017.1380080.

[5] W. Song, C. Gao, Y. Zhao, and Y. Zhao, “A time series data filling method based on lstm—taking the stem moisture as an example,” *Sensors (Switzerland)*, vol. 20, no. 18, pp. 1–21, 2020, doi: 10.3390/s20185045.

[6] A. Famili, W. M. Shen, R. Weber, and E. Simoudis, “Data preprocessing and intelligent data analysis,” *Intell. Data Anal.*, vol. 1, no. 1, pp. 3–23, 1997, doi: 10.3233/IDA-1997-1102.

[7] T. Kavzoglu, “Increasing the accuracy of neural network classification using refined training data,” *Environ. Model. Softw.*, vol. 24, no. 7, pp. 850–858, 2009, doi: 10.1016/j.envsoft.2008.11.012.

[8] A. E. dan M. N. A. R. Chopra, “Data Science with Python: Combine Python with machine learning principles to ... - Rohan Chopra, Aaron England, Mohamed Noordeen Alaudeen - Google Books,” 2019. https://books.google.co.id/books?hl=en&lr=&id=RYmkDwAAQBAJ&oi=fnd&pg=PP1&dq=R.+Chopra,+A.+England+dan+M.+N.+Alaudeen,+Data+Scie

ISSN: 2252-4274 (Print)
ISSN: 2252-5459 (Online)

nce+with+Python,+Birmingham:+Packt+Publishing+Ltd.,+2019.&ots=IbfPm2ENUh&sig=DC0ExNpmO_Jiiy8bjqBhSNl86qM&redir_esc=y#v=snippet&q=transformation&f=false (accessed Oct. 01, 2022).

[9] R. J. Chadalavada, S. Raghavendra, and V. Rekha, "Electricity requirement prediction using time series and Facebooks PROPHET," *Indian J. Sci. Technol.*, vol. 13, no. 47, pp. 4631–4645, 2020, doi: 10.17485/ijst/v13i47.1847.

[10] P. M. Services, "The 'Rapid Application Development' Methodology Approach (RAD) -," 2020. https://cooens.com/knowledge-base/the-rapid-application-development-methodology-approach-rad/ (accessed Dec. 29, 2021).

[11] B. L. Ruddell and P. Kumar, "Unified modeling language," *Hydroinformatics Data Integr. Approaches Comput. Anal. Model.*, no. 10, pp. 9–20, 2005, doi: 10.4018/jdm.2001010103.