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Monitoring System for Website-Based Micro Hydro Power Plant using Firebase

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Abstract – *The use of electrical energy is a basic need for everyone. Micro Hydro Power Plant is one of the technologies that has developed recently. This technology has little adverse impact on the environment. This plant utilizes flowing water, discharge from water, and water pressure. The highlands or mountainous areas where there is flowing water. This water flow can be used as a driving force to drive a turbine, which is the driving force for this power plant because the generator uses a generator that requires motion power to generate electricity. Because this plant utilizes flowing water as a power source to drive a turbine and turn a generator. So basically, where there is running water, there is electricity. Moreover, micro Hydro does not need to build large reservoirs like hydropower. The purpose of making this system is to make it easier to check the condition of the MHP equipment and record the data obtained from the sensors that have been installed. This Website was successfully implemented using HTML, PHP, Firebase Database, CSS, JavaScript, JSON, etc. This Website will use the waterfall method, which consists of observation and needs analysis, system design, modeling, implementation and coding, testing, and maintenance.*

Keywords: *Micro Hydro Power Plant, MHP, Website, Monitoring System, Firebase.*

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Abstrak – *Penggunaan energi listrik merupakan kebutuhan dasar bagi setiap orang. Pembangkit Listrik Tenaga Mikrohidro merupakan salah satu teknologi yang telah berkembang akhir-akhir ini. Teknologi ini memiliki dampak yang kecil terhadap lingkungan. Pembangkit ini memanfaatkan air yang mengalir, debit air, dan tekanan air. Dataran tinggi atau daerah pegunungan yang terdapat air yang mengalir. Aliran air ini dapat digunakan sebagai tenaga penggerak untuk menggerakkan turbin yang merupakan tenaga penggerak pembangkit listrik ini karena pembangkit ini menggunakan generator yang membutuhkan tenaga gerak untuk menghasilkan listrik. Karena pembangkit ini memanfaatkan air yang mengalir sebagai sumber tenaga untuk menggerakkan turbin dan memutar generator. Jadi pada dasarnya, di mana ada air mengalir, di situ ada listrik. Selain itu, mikrohidro tidak perlu membangun waduk yang besar seperti PLTA. Tujuan dari pembuatan sistem ini adalah untuk mempermudah dalam melakukan pengecekan kondisi peralatan PLTMH dan pencatatan data-data yang diperoleh dari sensor-sensor yang telah dipasang. Website ini berhasil diimplementasikan dengan menggunakan HTML, PHP, Firebase Database, CSS, JavaScript, JSON, dll. Website ini akan menggunakan metode waterfall, yang terdiri dari observasi dan analisis kebutuhan, desain sistem, pemodelan, implementasi dan pengkodean, pengujian, dan pemeliharaan.*

Kata Kunci: *Pembangkit Listrik Tenaga Mikro Hidro, PLTMH, Website, Sistem Pemantauan, Firebase.*

I. INTRODUCTION

The advancement and rapid development of technology have made it increasingly easier to utilize various resources in our daily lives. This includes exchanging news via mobile phones, staying updated with the latest information through television broadcasts, and much more. Central to these technologies is electrical energy, which serves as the essential power source that keeps them operational. The Coordinating Minister for Human Development and Culture, Muhadjir Effendy, has highlighted the importance of meeting electricity demands by leveraging alternative energy sources. These should be tailored to the specific needs of the budget, village characteristics, human resources, geography, and available energy sources. He emphasized that relevant ministries and agencies, including the Ministry of Energy and Mineral Resources (ESDM), the State Electricity Company (PLN), the Ministry of Villages, Development of Disadvantaged Regions, and Transmigration (Kemendes PDTT), along with private sector partners, should collaborate to maximize efforts in utilizing alternative energy for electricity, ensuring it aligns with regional characteristics [1].

Given this context, electrical energy has become a fundamental necessity for everyone. Many devices, whether high-voltage or low-voltage, operate on electric power. One of the emerging technologies in this domain is the Microhydro Power Plant (MHP), which is environmentally friendly and operates by harnessing the energy of flowing water, water discharge, and water pressure, especially in highland or mountainous areas where water flows are abundant. This flowing water drives the turbine, which in turn powers the generator to produce electricity. For this plant to function, a continuous stream of water is essential. Unlike large hydropower plants, microhydro plants do not require the construction of large reservoirs [2], [3], [4].

Moreover, with the rapid pace of technological advancements and the limited availability of electrical energy sources in certain areas, it is crucial to explore alternative sources of electricity. In many mountainous regions, there are still places where conventional electricity has yet to reach. However, these areas often have water streams that flow year-round, making them suitable for microhydro power generation. Once the MHP is established, regular monitoring is necessary to prevent equipment damage [5].

Integrating the Microhydro Power Plant with the Internet of Things (IoT) offers a solution for remote monitoring, eliminating the need for physical visits to the MHP site. This approach is particularly valuable in areas where PLN's electricity grid does not extend. With this system, it is possible to generate electricity locally, addressing the issue of power shortages. The remote monitoring capability also helps in maintaining the plant by allowing checks to be performed without the need for an on-site visit. This is particularly useful in locations that are difficult to access due to long distances, poor road conditions, or other logistical challenges [6], [7].

Some of the literature reviewed for this research still have some gaps. The first reference is from a study titled "Output Monitoring System on IoT (Internet of Things) Based Microhydro Power Plant," published in 2020 by Hilmi Fauzi, Yulianto, and Supriatna Adhisuwignjo. This study focuses on the MHP generator's ability to produce observable quantities such as voltage, current, and speed values. Traditionally, monitoring these quantities required the operator to be physically present at the plant, which made monitoring less efficient and timely. To address this, the study proposed a remote monitoring system that uses the internet to transmit sensor data. The sensor readings are displayed on a web interface and an Android application, with data transmission facilitated by an ESP8266 controller, Firebase Console, and MIT App [8].

The second reference is from a 2017 study titled "Internet of Things Based Water Level Monitoring System Using Google Firebase," by Eljire Bagas Lewi, Unang Sunarya, S.T., M.T., and Dadan Nur Ramadan, S.Pd., M.T. This study presents a concept based on the Internet of Things (IoT), where an ultrasonic sensor reads the water level and sends the data to a web server via the internet, storing it in Firebase, which is integrated with an Android application. The study found an average delay of 0.514 seconds in transmitting data from the database to the application and 6.69 seconds from the hardware to the application. Additionally, the average data usage was 0.64 MB per hour during idle conditions. The application can display the location of the monitoring device, with programmed water level statuses categorized as Safe, Alert, and Danger. When the water level exceeds a specified limit, the Android application issues a "Danger. Water level exceeds the limit!" notification [9].

The third reference is from a 2020 study titled "Design of Voltage, Current, and Frequency Monitoring Systems in IoT-Based Microhydro Power Plants," by Muhammad Zaini, Safrudin, and Moh. Bachrudin. This study discusses how microhydro power plants operate by utilizing the height of falling water, water discharge, and water pressure, converting this energy into mechanical energy to drive a turbine. The mechanical energy is then converted into electrical energy through a generator. Due to power losses and time factors, regular monitoring of microhydro plants is necessary. The study proposed a design for a monitoring system that tracks voltage, current, and frequency in microhydro power plants using IoT. The system uses an ESP32 microcontroller board to read and process sensor data, which is then transmitted via Wi-Fi to the Ubidots platform for monitoring and notification purposes. Notifications and control of the solid-state relay (SSR) are managed through Telegram messages [10]

Another reference is from a 2016 study titled "Design of Microcontroller-Based Current and Voltage Monitoring Tools with SMS Gateway," by Afrizal Fitriandi, Endah Komalasari, and Herri Gusmedi. This study focuses on monitoring current and voltage in hybrid Micro Hydro Power Plant and Solar Power Plant systems, using a microcontroller-based tool with an SMS gateway for easier monitoring [11].

The final reference is a 2018 study titled "JustIoT: Internet of Things based on Firebase Real-time Database." This study discusses the creation of a smart home system using Firebase Realtime-Database for the back-end and Single Page Application (SPA) for the front-end. The smart home system is divided into four parts: humidity, temperature, and brightness sensors as inputs, and living room light and bedroom mood light as outputs. The system is controlled by an Arduino connected to an MQTT server, with monitoring and control done through a web display called JustIoT [12].

From all the literature reviewed, it's clear that using a monitoring system in Micro Hydro Power Plants enables regular monitoring, which is crucial for maintaining the plant's efficiency. Combining ideas from these studies, such as monitoring current and voltage through a power supply, can lead to more effective monitoring solutions. Traditionally, MHP users had to visit the powerhouse, typically built along the riverbank, to check the water discharge and the electrical output. This process is time-consuming and labor-intensive.

In this research, the author has developed a Monitoring System for a Website-Based Micro Hydro Power Plant using Firebase, allowing remote monitoring of current, voltage, and water level produced by the MHP, eliminating the need for direct visits to the site.

II. RESEARCH METHOD

This research employs the waterfall method, a sequential software development process where progress is visualized as flowing downwards in a linear fashion—similar to a waterfall—through phases such as design, modeling, implementation (construction), and testing.

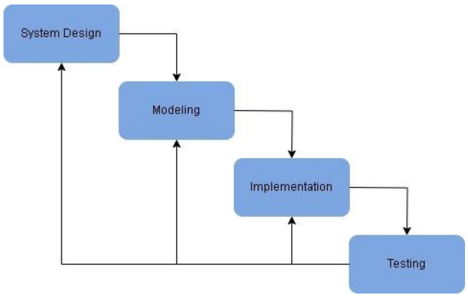


Figure 1. Waterfall Method

The waterfall model is a straightforward, traditional approach where the output from one stage serves as the input for the next. This model originated as an adaptation of hardware development processes, as there were no other software development methodologies available at the time. Its highly structured nature significantly minimizes the risk of errors from earlier stages impacting later stages [13].

A. System Design

System design involves translating the requirements of a website into a blueprint that can be evaluated before moving on to the next phase. This step focuses on designing the entire system, including the website's structure, layout, and use cases. This planning is essential to ensure that the website can effectively interact with other components, such as databases and external systems [14].

1. *Whole System Design*

Micro-hydro power plants operate by harnessing water flow and pressure. The energy from this water flow and pressure is converted from mechanical energy into electrical energy by driving a turbine [15], [16], [17]. The overall design of the system is illustrated in Figure 2.

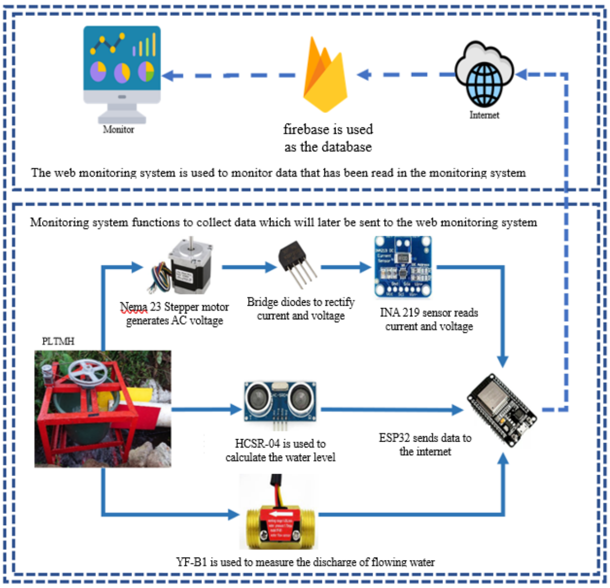


Figure 2. Whole System Design

In this research, several components were utilized to build the system. The turbine was connected to a stepper motor, which converts mechanical energy into electrical energy. Since the output from the stepper motor is in AC (alternating current), a converter component was required to transform the current into DC (direct current) using a diode bridge. Once the current is converted to DC, it is connected to an INA219 sensor, which is interfaced with the

ESP32 microcontroller. Additionally, an ultrasonic sensor is used to measure the water level, and a water flow sensor is employed to measure the flow rate of the water. The data collected by the microcontroller is then processed and sent to a Firebase database. This data is subsequently retrieved from the database and displayed on a website, allowing for monitoring of parameters such as current, voltage, and water flow in the Microhydro Power Plant (MHP) [18].

The system design features three sensors connected to the ESP32 microcontroller: the HC-SR04 Ultrasonic Sensor, the INA219 Sensor, and the YF-B1 Water Flow Sensor. The HC-SR04 sensor operates by emitting ultrasonic waves at a frequency of 40 kHz with a duration of 10 microseconds to measure the distance to an object. It has a maximum range of 400 cm and a minimum range of 2 cm, with a measurement angle of 15 degrees and an accuracy of up to 3 mm. In this system, the HC-SR04 sensor is directed at the water flow to determine its height [19].

The YF-B1 water flow sensor is designed to measure the flow rate of water in the system. When water flows through the sensor's rotor, the rotor spins, with its speed corresponding to the water flow rate. A hall-effect sensor then generates signal pulses from the rotor's movement, which are processed by the microcontroller. The frequency of these pulses, generated per second, represents the pulse signal frequency. This frequency can be calculated using the formula f=7.5×Qf = 7.5 \times Qf=7.5×Q, where QQQ is the water flow rate in liters per minute (L/min) [20]. The water flow sensor can handle flow rates up to 25 L/min and withstand pressures up to 1.5 MPa, with a minimum insulation resistance of 100M ohms.

The INA219 sensor is used as an alternative to the ACS712 sensor module for measuring DC currents. This sensor can measure voltages up to 26 VDC and currents up to 3.2 A with a precision of 1%. It employs an amplifier with a maximum input of ±320 mV to measure currents up to ±3.2 A, with a resolution of 0.8 mA. When the internal gain is set to a minimum of div8, the sensor can measure currents up to ±400 mA with a resolution of 0.1 mA. Additionally, the sensor is capable of measuring shunt voltages within the range of 0-26 V. The ESP32 microcontroller sends the collected data to the Firebase database every 15 seconds, from which the data is retrieved and displayed on the website for monitoring.

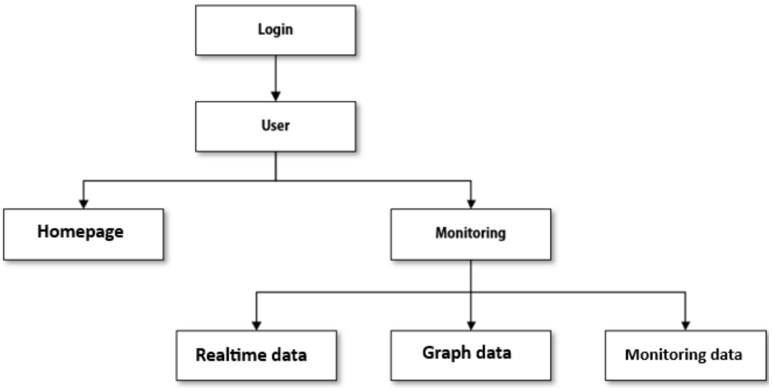


Figure 3. Website Structure

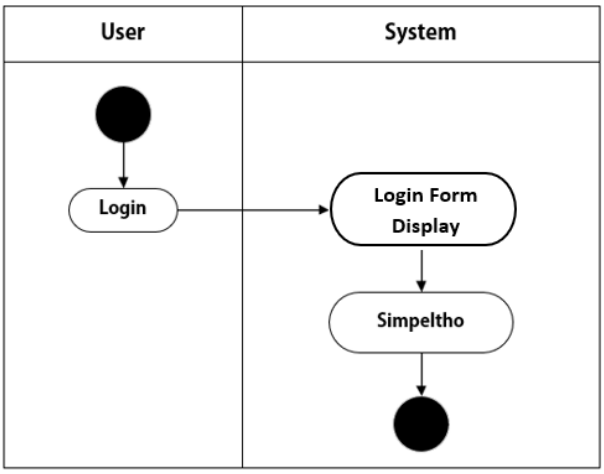


Figure 4. Website Activity Diagram

2. *Website Structure*

Figure 3 illustrates the website structure utilized in this research. The website is designed to be single-level and serves solely for monitoring microhydropower equipment.

3. *Website Design*

The website design facilitates the connection between the hardware and software components used in this system. Figure 4 depicts the activity diagram of the web system, showcasing the flow of activities on the website. Although the website is single-level, the process begins with an entry form before proceeding further.

Figure 5 provides an overview of the web system. After users access the website, they can monitor various parameters. The website retrieves data from the Firebase database, which includes output metrics such as voltage, current, turbine speed, water flow rate, and water level [21].

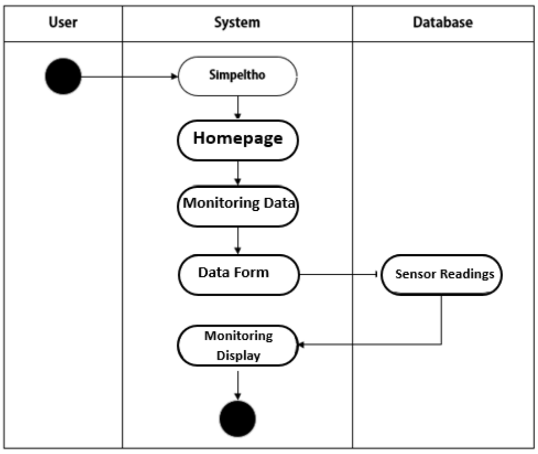


Figure 5. Website System Diagram

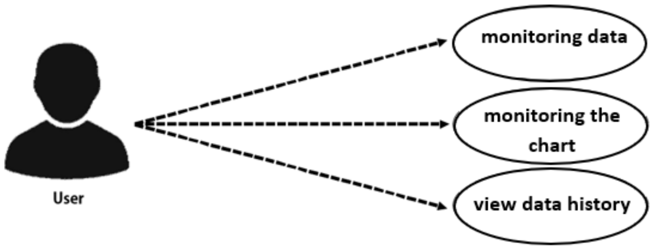


Figure 6. Website Use Case Diagram

Figure 7. Home Page

4. *Use Case*

Given that the website is designed to operate on a single level, the use case diagram relevant to this research is depicted in Figure 6.

B. Modeling

At this stage, the requirements gathered from the previous steps are transformed into a blueprint for the website. This blueprint serves as a guide for the subsequent development stages, ensuring that the website can fulfill the needs identified earlier [22], [23].

1. *Home Page Modeling*

Figure 7 presents the home page of the website. Although the website is single-level, the home page features a straightforward design that includes only the title and a login button. The login button facilitates access to the website's functionalities.

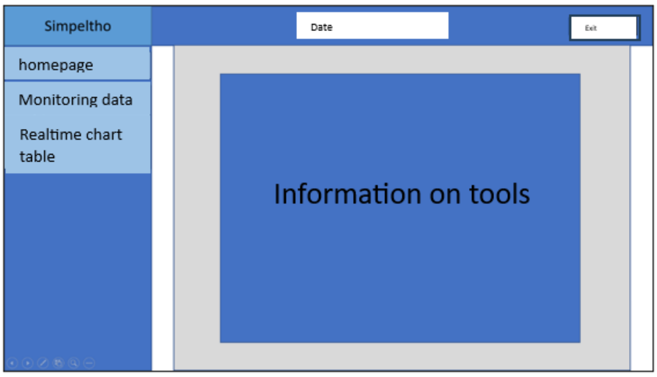


Figure 8. Home Page

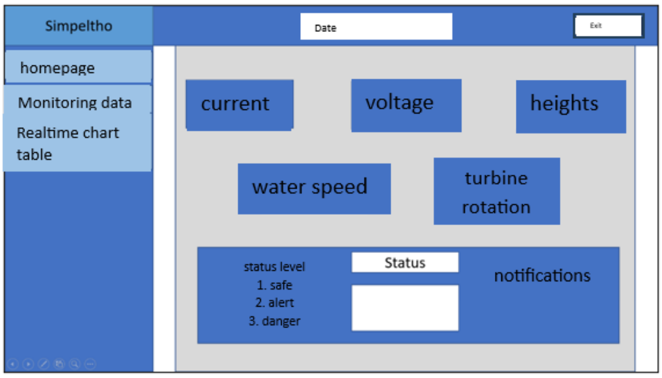


Figure 9. Real-time Data Page

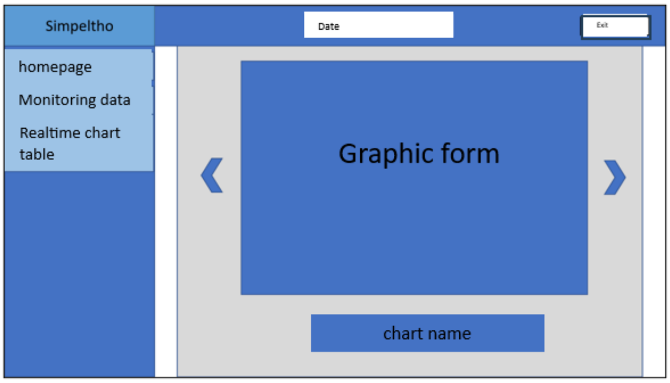


Figure 10. Graph Data Page

2. *Home Page Modeling*

Figure 8 illustrates the home page that users are directed to after logging in. This page provides essential information about microhydropower plants.

3. *Real-Time Data Page Modeling*

Figure 9 depicts the real-time data page, where users can view current data and receive notifications regarding water levels and water conditions. The water level status is categorized into three levels: safe, alert, and dangerous.

4. *Modeling of Graph Data Page*

Figure 10 shows the graph data page, which displays visual representations of sensor data within the monitoring system. The graphs include various parameters such as voltage, current, water level, water speed, and turbine output.

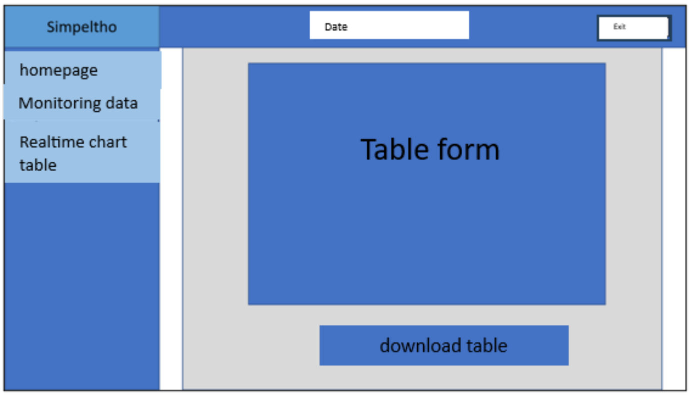


Figure 11. Table Data Page

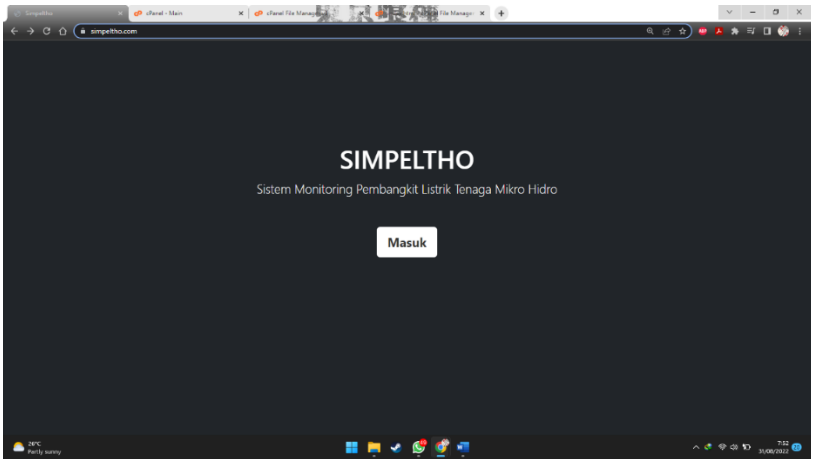


Figure 12. Login Page Implementation

5. *Modeling the Data Table Page*

Figure 11 contains data in tabular form and several features to download data in several formats. There are formats for downloading in pdf, excel, and csv. There are also features to print and copy table data.

III. RESULT AND DISCUSSION

A. Web Interface Design Testing

The web interface design includes several key components: the login page, home page, real-time data page, graph data page, and table data page. The following sections describe the implementation of each page.

1. *Login Page Implementation*

The login page is the first page users encounter after entering the website URL (e.g., simpeltho.com). This page features a button that, when clicked, directs users to the home page. The login page implementation is depicted in Figure 12.

2. *Home Page Implementation*

The home page provides information about the microhydro power plant and features a navigation bar with links to the Real-time Data, Graphs, and Tables sections. Additionally, the home page displays the current date at the top center and includes an exit button that allows users to return to the entry page or login page. The implementation of the home page is illustrated in Figure 13 below.

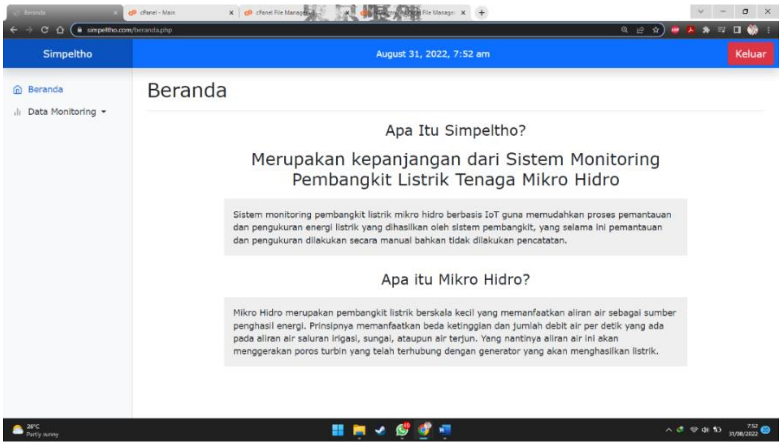


Figure 13. Home Page Implementation

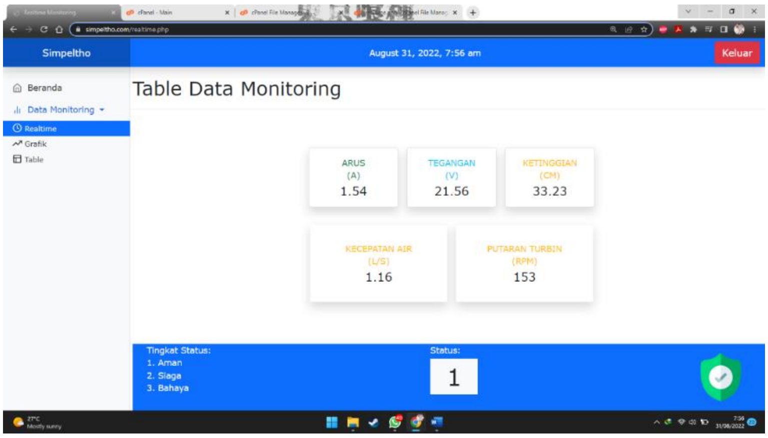


Figure 14. Real-time Data Page Implementation

3. *Real-Time Data Page Implementation*

The real-time data page displays the current data being received from the sensors installed on the device generator, along with notifications regarding the status of the water level. There are three possible conditions based on the water level:

- Safe Condition: Indicates that the water level is still well below the sensor, at a distance of about 0-15 cm.
- Alert Condition: Indicates that the water level is approaching the sensor, at a distance of around 16-30 cm.
- Danger Condition: Indicates that the water level has exceeded the safe limit, surpassing the sensor's height, which is set at 40 cm above the water surface.

In this implementation, the real-time data displayed as "0" due to a connection failure between the sensor and the ESP32, which resulted in the sensor data not being transmitted to the database. The real-time data page implementation is shown in Figure 14.

4. *Implementation of Graph Data Page*

The graph data page presents the sensor data in graphical form, which is retrieved from the database. This page displays five key metrics: Voltage, Current, Water Speed, Water Level, and Turbine Rotation. Similar to the real-time data page, the graph results also show "0" because of a connection failure between the sensor and the ESP32, which prevented the sensor data from being sent to the database.

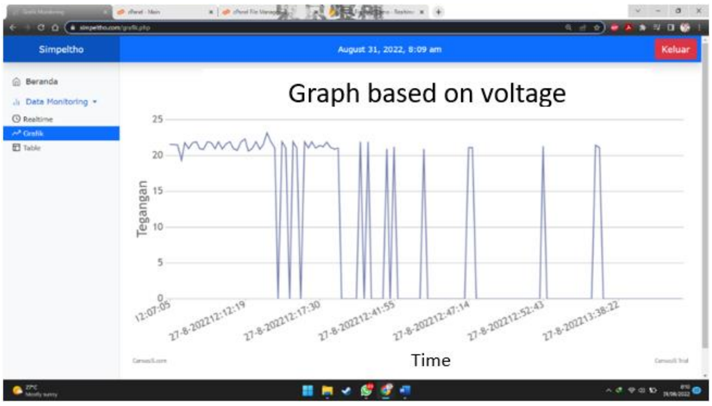


Figure 15. Implementation of Graph Data Page (Voltage)

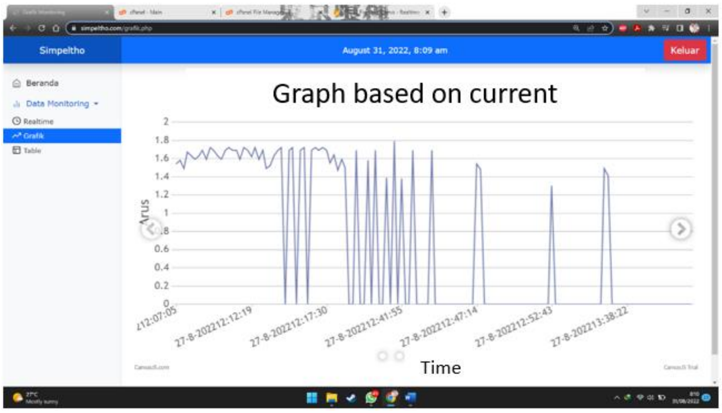


Figure 16. Implementation of the Data (Flow) Page

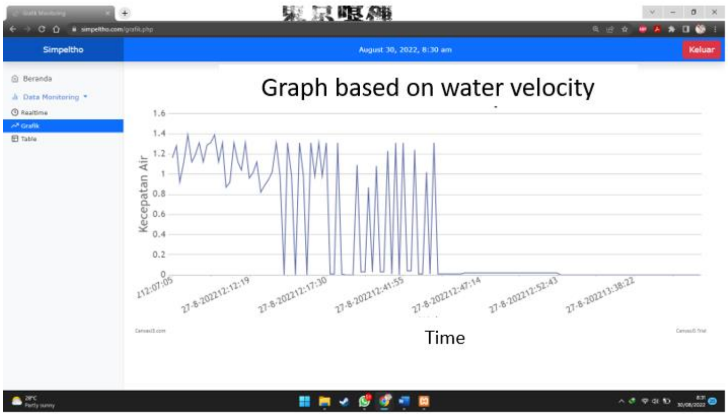


Figure 17. Implementation of Data Page (Water Speed)

The implementation of the graph data page (Voltage) is shown in Figure 15. Figure 16 is the implementation of the graph data page containing sensor data from the current. Then, in Figure 17 is the implementation of the graph data page containing sensor data from water speed.

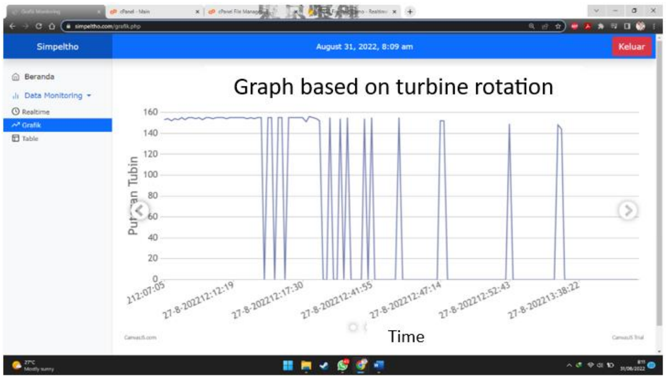


Figure 18. Implementation of Data Page (Turbine Rotation)

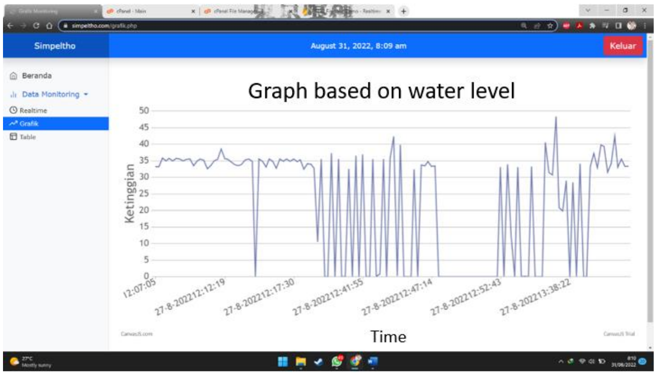
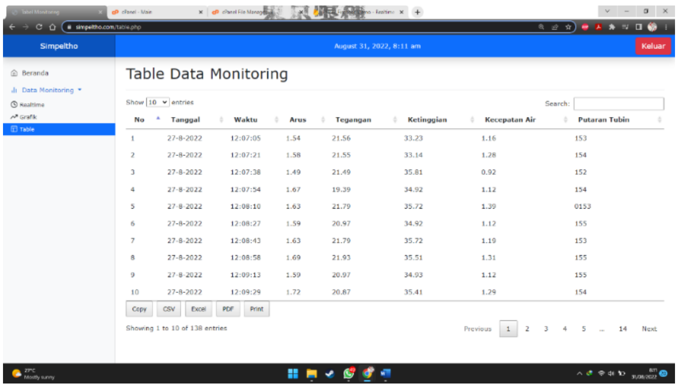


Figure 19. Implementation of Data Page (Water Level)



August 31, 2022, 8:11 am

Table Data Monitoring

Show 10 entries

No	Tanggal	Waktu	Arus	Tegangan	Ketinggian	Kecepatan Air	Putaran Tubin
1	27-8-2022	12:07:05	1.54	21.56	33.23	1.16	153
2	27-8-2022	12:07:21	1.58	21.55	33.14	1.28	154
3	27-8-2022	12:07:38	1.49	21.49	35.81	0.92	152
4	27-8-2022	12:07:54	1.67	19.39	34.92	1.12	154
5	27-8-2022	12:08:10	1.63	21.79	35.72	1.39	0153
6	27-8-2022	12:08:27	1.59	20.97	34.92	1.12	155
7	27-8-2022	12:08:43	1.63	21.79	35.72	1.19	153
8	27-8-2022	12:08:58	1.69	21.93	35.51	1.31	155
9	27-8-2022	12:09:13	1.59	20.97	34.93	1.12	155
10	27-8-2022	12:09:29	1.72	20.87	35.41	1.29	154

Copy CSV Excel PDF Print

Showing 1 to 10 of 138 entries

Previous 1 2 3 4 5 … 14 Next

Figure 20. Implementation of Data Page (Table)

Figure 18 is the implementation of the graph data page containing sensor data from turbine rotation. Figure 19 is the implementation of the graph data page containing sensor data from the water level.

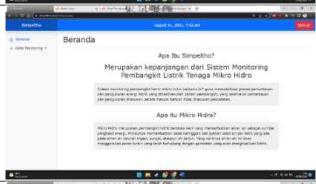
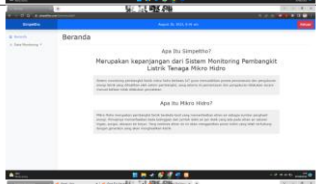
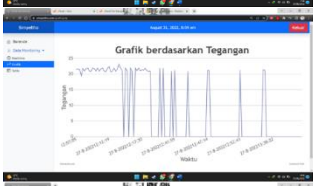
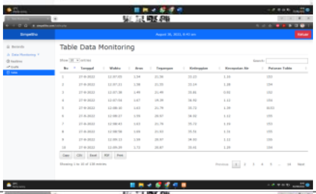
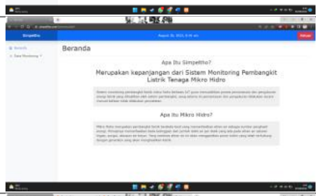
5. *Implementation of Table Data Page*

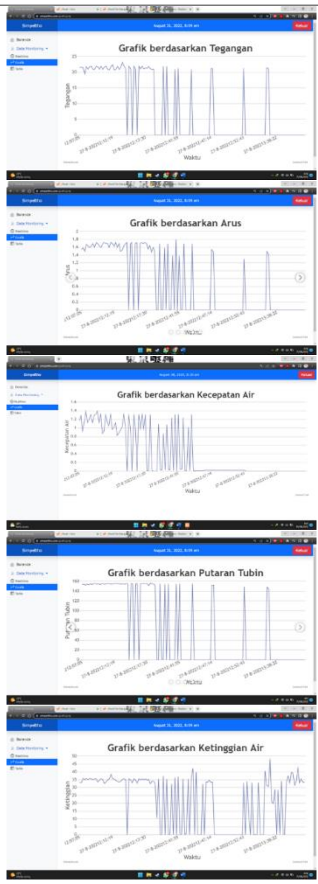
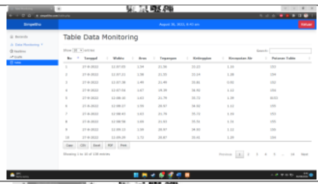
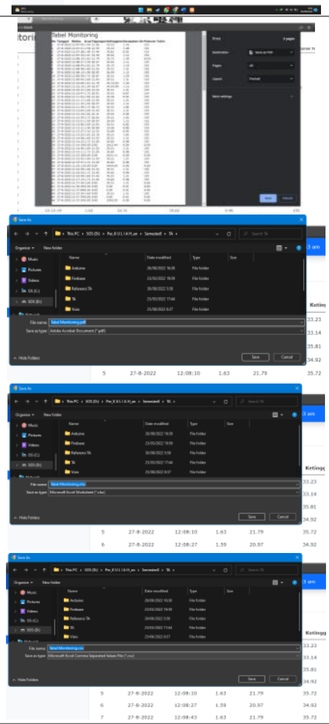
As shown in Figure 20, the table data page contains data in tables that are available in a database. There are several features in the table, such as several options to display the number of tables (10, 25, 50, 100) and several options about what to do with the data in the table. The result in the table is "0" because there is a connection failure from the sensor to the ESP32, so the data from the sensor is not sent to the database.

B. System Testing Results

This study used black box testing and response time testing to test the system. The results of black box testing can be seen in Table 1, while the results of response time testing can be seen in Table 2 below.

TABLE 1
BLACK BOX TESTING RESULTS

No.	Testing	Actor	Expected Results	Accepted Results	Conclusion
1.	Testing the login page	*User*	It can display the button to enter		Accurate
2.	Login button test	*User*	Go to the home page		Accurate
3.	Testing the exit button	*User*	Go to the login page		Accurate
4.	Testing dashboard menu options	*User*	Go to the page corresponding to the selection	   	Accurate
5.	Home page testing	*User*	Bring up information about Simpeltho		Accurate
6.	Testing the real-time data page	*User*	Display all sensor data connected to the database		Accurate

7.	Testing the graph data page	_User_	Display each data in graphical form		Accurate
8.	Testing the table data page	_User_	Display all sensor data connected to the database		Accurate
9.	Testing menu options on the table data page	_User_	Can be used according to predetermined conditions		Accurate

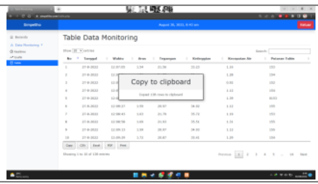


TABLE 2
RESPONSE TIME TEST RESULTS

No.	*Bandwidth* (Mbps)	Actor	Object	Time (ms)
1.	5	*User*	Login Page	754
			Home Page	411
			Monitoring Data (Real-time)	834
			Monitoring Data (Graph)	877
			Monitoring Data (Table)	1,885
2.	10	*User*	Login Page	454
			Home Page	565
			Monitoring Data (Real-time)	882
			Monitoring Data (Graph)	886
			Monitoring Data (Table)	1,855
3.	15	*User*	Login Page	557
			Home Page	658
			Monitoring Data (Real-time)	853
			Monitoring Data (Graph)	868
			Monitoring Data (Table)	1,655

Based on the response time data above, it shows that the Website that has been created is classified as good because nothing exceeds 2 seconds. Even though only one user is used to access the Website. Then, there is a longer response time on a larger bandwidth because the size of the downlink and uplink bandwidth owned in each bandwidth test varies depending on the bandwidth distribution in each network provider. However, the difference in response time does not exceed 1 second. The results of the testing of the micro-hydro power plant monitoring system developed show that all main functions of the system are operating well, as measured through the black box method. This testing successfully displayed the button to enter the login page and directed users to the main page after logging in, indicating that the system has good access control, which is essential for maintaining the security of user data and information. Furthermore, all sensor data connected to the database is displayed accurately, which is key in monitoring, allowing users to monitor the condition of the power plant in real-time. Users can also access various menus according to the specified conditions, indicating that the user interface is well-designed, facilitating navigation and interaction with the system. The positive test results indicate that the developed monitoring system meets the research objectives, which are to facilitate the checking of the condition of the micro-hydroelectric power plant equipment and the recording of data from the installed sensors. This system successfully provides a platform that enables remote monitoring, which is crucial in remote areas where physical access to power generation sites may be difficult. By using Firebase as a real-time database, this system can provide users with up-to-date information without the need for a physical visit to the location. In addition, the test results show that the system not only functions well but is also efficient in displaying data, which is crucial to ensure that users can make quick and accurate decisions based on reliable information.

Although the test results indicate good performance, there is room for further development, such as the addition of analytical features to predict equipment failures or integration with early warning systems, which would enhance the system's ability to maintain the operations of micro-hydropower plants. The use of IoT technology and Firebase in this system also demonstrates relevance to current technological trends in monitoring system development, which not only improves efficiency but also provides more sustainable solutions to energy issues in remote areas. Thus, the positive test results and in-depth analysis show that the developed monitoring system not only meets the research objectives but also makes a significant contribution to the development of renewable energy technology in areas in need.

IV. CONCLUSION

Based on the test results, it can be concluded that this monitoring system provides data on voltage, current, water speed, turbine speed, and water level in the form of numbers, graphs, and tables that allow users to monitor the condition of the power plant directly, saving time, costs, and energy. Users can monitor this system more effectively and efficiently, anywhere and anytime. System testing using black box and response time methods show that the website features function properly and the website response time is quite good, not exceeding 2 seconds, even at various uplink and downlink speeds. At 5 Mbps bandwidth, the highest response time is 1.885 ms., 10 Mbps is 1.855 ms, and 15 Mbps is 1.655 ms.

REFERENCES

[1] IEA, "Energy Policy Review - Greece," pp. 1–167, 2023.
[2] M. Pineng and J. E. Pérez, "Penggunaan Mikrokontroler Pada Sensor Suhu," *Pendidik. Fis.*, vol. 1, p. 4, 2018.
[3] A. M. Al Bawani and S. Sudarti, "ANALISIS KELEMAHAN DAN KELEBIHAN PEMBANGKIT LISTRIK TENAGA MIKROHIDRO (PLTMH) SEBAGAI ALTERNATIF SUMBER ENERGI LISTRIK," *J. Kumparan Fis.*, vol. 5, no. 2, pp. 99–104, Sep. 2022, doi: 10.33369/JKF.5.2.99-104.
[4] B. Sumiyarso, R. Ajeng Rochmatika, F. Tono Putri, T. Prahara, J. Teknik Elektro, and P. H. Negeri Semarang Jl Sudarto, "SISTEM MONITORING PEMBANGKIT LISTRIK TENAGA MIKRO HIDRO BERBASIS IOT," *Pros. Semin. Has. Penelit. dan Pengabdi. Masy.*, vol. 4, no. 1, May 2022.
[5] R. Syahputra, R. M. Fasha, A. Nur, N. Chamim, and K. Purwanto, "Prototipe Sistem Monitoring pada Pembangkit Listrik Tenaga Mikrohidro," *Semesta Tek.*, vol. 25, no. 1, pp. 40–46, May 2022, doi: 10.18196/ST.V25I1.13180.
[6] R. Mauliyana, M. Wilutomo, and T. Yuwono, "RANCANG BANGUN MEMONITOR ARUS DAN TEGANGAN SERTA KECEPATAN MOTOR INDUKSI 3 FASA MENGGUNAKAN WEB BERBASIS ARDUINO DUE," *Gema Teknol.*, vol. 19, no. 3, pp. 19–24, Oct. 2017, doi: 10.14710/GT.V19I3.21881.
[7] E. Adrin Wihelmus Sanadi, A. Achmad, J. Poros Malino Km, K. Gowa, and S. Selatan, "Pemanfaatan Realtime Database di Platform Firebase pada Aplikasi E-Tourism Kabupaten Nabire," *J. Penelit. Enj.*, vol. 22, no. 1, pp. 20–26, May 2018, doi: 10.25042/JPE.052018.04.
[8] H. Fauzi, Y. Yulianto, and S. Adhisuwignjo, "Sistem Monitoring Keluaran Pada Pembangkit Listrik Tenaga Mikrohidro Berbasis IOT (Internet Of Things)," *J. Elektron. dan Otomasi Ind.*, vol. 7, no. 1, p. 45, Mar. 2021, doi: 10.33795/elkolind.v7i1.179.
[9] E. B. Lewi, U. Sunarya, and D. N. Ramadan, "Sistem Monitoring Ketinggian Air Berbasis Internet of Things Menggunakan Google Firebase," *Univ. Telkom, D3 Tek. Telekomun.*, vol. 1, no. 1, pp. 1–8, 2017.
[10] M. Zaini, S. Safrudin, and M. Bachrudin, "Perancangan Sistem Monitoring Tegangan, Arus Dan Frekuensi Pada Pembangkit Listrik Tenaga Mikrohidro Berbasis Iot," *TESLA J. Tek. Elektro*, vol. 22, no. 2, p. 139, 2020, doi: 10.24912/tesla.v0i0.9081.
[11] A. Fitriandi, E. Komalasari, and H. Gusmedi, "Rancang Bangun Alat Monitoring Arus dan Tegangan Berbasis Mikrokontroler dengan SMS GatewayRancang Bangun Alat Monitoring Arus dan Tegangan Berbasis Mikrokontroler dengan SMS Gateway," *Electr. J. Rekayasa dan Teknol. Elektro*, vol. 10, no. 2, pp. 87–98, Jul. 2016, doi: 10.23960/ELC.V10N2.215.
[12] W. J. Li, C. Yen, Y. S. Lin, S. C. Tung, and S. M. Huang, "JustIoT Internet of Things based on the Firebase real-time database," *Proc. - 2018 IEEE Int. Conf. Smart Manuf. Ind. Logist. Eng. SMILE 2018*, vol. 2018-January, pp. 43–47, May 2018, doi: 10.1109/SMILE.2018.8353979.
[13] C. Tristianto, "Penggunaan metode waterfall untuk pengembangan sistem monitoring dan evaluasi pembangunan pedesaan," in *ESIT*, 2018, pp. 8–22.
[14] Maciej Serda *et al.*, "Traditional Infrastructure Vs Firebase Infrastructure," *Int. J. Sci. Res. Dev.*, vol. 5, no. 4, pp. 1287–1289, Jul. 2017, doi: 10.2/JQUERY.MIN.JS.
[15] I. G. Widharma Saputra, "Pembangkit Listrik Tenaga Mikro Hidro (Application of Distributed Control System)," no. May, 2021, doi: 10.13140/RG.2.2.30435.48162.
[16] H. Suripto and S. Anwar, "Desain dan Pengembangan Prototipe Alat Uji Pembangkit Listrik Tenaga Mikro Hidro dengan Back Flow Water System," *JTERA (Jurnal Teknol. Rekayasa)*, vol. 5, no. 2, p. 221, 2020, doi: 10.31544/jtera.v5.i2.2020.221-230.
[17] A. R. C. Baswara and R. Alfaqi, "Rancang Bangun Sistem Monitoring Pembangkit Listrik Tenaga Mikro Hidro Berbasis Internet Of Things (IoT)," *J. Teknol. Elektro*, vol. 14, no. 01, 2023.
[18] F. Apriadi and E. Prayogi, "PROSES MANUFAKTUR PEMBANGKIT LISTRIK TENAGA MIKROHIDRO," *J. Ilm. Tek. MESIN*, vol. 10, no. 1, pp. 1–7, Feb. 2022, doi: 10.33558/JITM.V10I1.2982.
[19] A. S. M. Ahsanul Akib, S. Mahmud, and M. F. Mridha, "Future Micro Hydro Power: Generation of Hydroelectricity and IoT based Monitoring System," *2021 Int. Conf. Innov. Intell. Informatics, Comput. Technol. 3ICT 2021*, pp. 298–302, Sep. 2021, doi: 10.1109/3ICT53449.2021.9581590.
[20] S. Suyanto, "Alat penakar volume air berbasis mikrokontroler," 2015.
[21] R. Z. Pratama and H. Nurwarsito, "Monitoring Penggunaan Daya Listrik menggunakan Protokol MQTT berbasis Web," *J. Pengemb. Teknol. Inf. dan Ilmu Komput.*, vol. 3, no. 11, pp. 10820–10826, 2019.
[22] R. Syahputra, R. M. Fasha, A. N. N. Chamim, K. Purwanto, and A. Jamal, "Design of a Smart Micro-hydro Monitoring System," *AIP Conf. Proc.*, vol. 2499, no. 1, Nov. 2022, doi: 10.1063/5.0105973/2827218.
[23] M. Fajar Ramadhani, "Pembangunan Aplikasi Informasi, Pengaduan, Kritik, Saran Seputar Kota Cimahi Pada Platfrom Android," Feb. 2016.