Vokasi Unesa Bulletin of Engineering, Technology and Applied Science (VUBETA)
https://journal.unesa.ac.id/index.php/vubeta
Vol. 1, No. 2, 2024, pp. 38~47 DOI: 10.26740/vubeta.v1i2.35411
ISSN: 3064-0768

Monitoring of Public Street Lighting Equipment Using Passive Infrared Receiver (PIR) Sensors and Node-red

Muhammad Ismail Faruqi[1], Dimas Herjuno[2]
[1]Department of Electrical Engineering, Faculty of Vocational, Universitas Negeri Surabaya, Surabaya, Indonesia
[2]Department of Life Science and Systems Engineering, Kyushu Institute of Technology, Fukuoka, Japan

Article Info

Article history:

Received October 18, 2024
Revised October 31, 2024
Accepted November 10, 2024

Keywords:

Street Lighting,
Passive Infrared Receiver Sensors
Node-red
Innovation

ABSTRACT

The current public street lighting system (PJU) still uses manual panel control. With these problems to find out the condition of the lights from the public street lighting (PJU) is running well or not and to find out whether the lights are on or off. From this statement, the purpose of this study is to determine 1) the sensitivity distance of the PIR (Passive Infrared Receiver) sensor with Movement on a microcontroller-based PJU to save electrical energy. 2) comparison of Current When measured using an ampere clamp and Node-red. The method used is experimental, namely Referring to two sets of variables. The first set functions as a constant. The results of the study show that 1) Based on the test results, it was found that the PIR sensor works when the human object is at a distance of 1 to 8 meters and can be detected objects in bright or dark conditions. 2) Based on the test results, it was found that the PZEM-004T sensor When given a load, the greater the current load given to the device, the current value read on the Node-red.

1. INTRODUCTION

In the current industrial generation (industry 4.0) the growth of technology is very rapid, with the growth of technology, systems are combined with various aspects that want to help human work become easier [1]–[10]. With the development of Internet of things technology, it changes the public street lighting system that has been applied so far [11]–[15]. The Internet of things is a concept where an item or object embeds technologies such as sensors and applications with the aim of talking, managing, connecting, and exchanging information through other features as long as it is still connected to the internet, The always active feature is an illustration of how IoT is used in everyday life [16]–[26].

In order to improve traffic safety and security, streetlights or often referred to as Public Street Lighting so that drivers can see it more clearly. The main purpose of Public Street Lighting is to provide artificial lighting for vehicle drivers so that they can travel comfortably and safely at night. Basically, the public street lighting system still operates manually, which is still done using manual control in the panel, where each lamp can only be controlled and controlled in the installed panel, but the installation of public street lighting manually is less suitable for repair and maintenance of lights. By using public street lighting manually, it will cause loss of time and is inefficient [27]–[32]. When at night the lights are often on continuously, used to light the road at night before the specified timer time, it causes a waste of electrical energy. With these problems to find out the condition of the lights from the Public Street Lighting (PJU) is working well or not and to find out whether the lights are on or off and to reduce the waste of electrical energy at night on public street lighting (PJU) can use the monitoring application from our smartphone, namely Node-red. The Node-red application is an application that aims to control Arduino, Raspberry Pi, ESP8266, ESP32 modules and similar modules internally, the reason for using Node-red is that the application is easy to use, very flexible, has an easy-to-understand concept, and can create monitoring programs directly without having to go through the training process.

*Corresponding Author
Email: m.ismail.19030@mhs.unesa.ac.id

2. METHOD

Public Street Lighting Monitoring is a system of tools consisting of components that are combined which consist of hardware and data loggers to process components that have been assembled so that they can be used. The supporting components of the hardware are applied in a PCB hole for assembly purposes so that the components can be applied as a tool that can later be used easily. Not only the hardware is needed, there is also a data logger as a component communication tool that later the components can run with the presence of a data logger that has been set and the data has also been entered into a component called ESP32

2.1. NodeMCU ESP 32

NodeMCU ESP32 ESP 32 is a microcontroller introduced by Espressif System, the successor to the ESP8266 microcontroller. This microcontroller has WiFi material on the chip, making it very supportive for creating an Internet of Things application system. As seen in Fig. 1 is the pinout of the ESP32. This pin can be used as input or output to turn on the LCD, lights, and even to drive a DC motor [33]–[36].

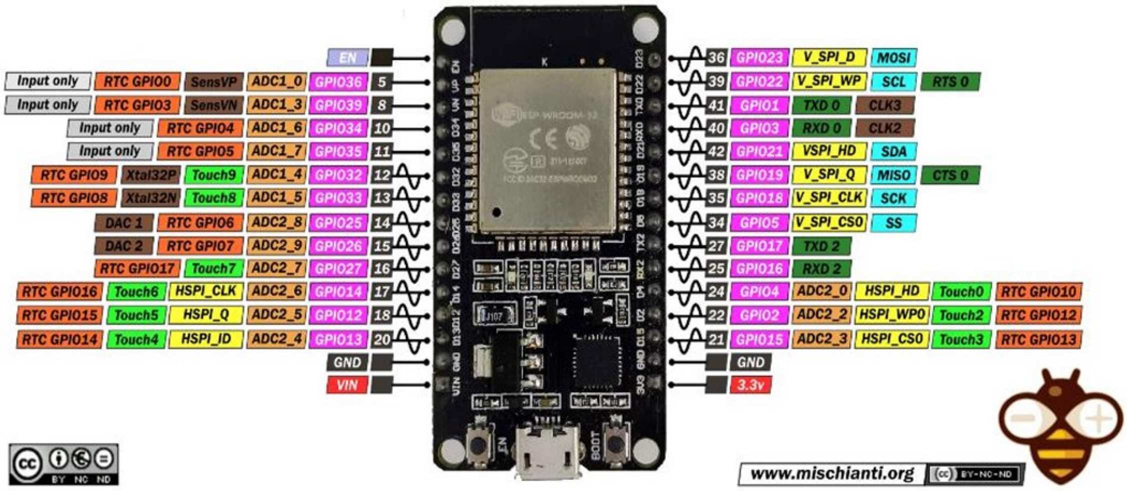

Figure 1 NodeMCU ESP32

NodeMCUESP 32 Useful features such as TCP/IP, HTTP, and FTP. This module is also equipped with analog signal processing features, support for sensors, and support for digital input/output (I/O) features. ESP32 also has a module for Bluetooth connectivity. Can be used to manage features connected to Bluetooth. ESP32 is very suitable for use in IoT (Internet of Things) projects. This module is able to connect features to the Internet network easily. ESP32 can be used in projects that require analog signal processing and digital I/O features. This module is easy to use and is available in the form of a separate module or an integrated circuit board (PCB) that is ready to use. ESP32 is a WiFi module developed by Espressif Systems which has complete features and good performance. This material is a development of the ESP8266 WiFi material.

There are 2 CPUs, each of which has a speed level of 80 MHz and 160 MHz. Not only that, the ESP32 also has many bonus features such as ADC, DAC, I2C, I2S, SPI, and UART for various applications. One of the most prominent features of the ESP32 is a module that is easy to connect to the internet. This module can be connected to a WiFi network using the TCP/IP protocol that allows. ESP32 talks to other features. Not only that, the ESP32 also has a Bluetooth feature to connect other features. The ESP32 is very suitable for use in Internet of Things (IoT) projects. This module can be used for other applications such as system control, monitoring, and others. There is 520 KB of memory to store the programs and information needed. Easy to use and there is a library that can be used to make it easier to develop applications. This module can be programmed with the C or C ++ programming language.

Overall, ESP32 is a complete and quality WiFi module for various IoT projects. With complete features and affordable prices, ESP32 is the right choice for wireless communication needs. If you are looking for a professional and easy-to-use WiFi module. ESP32 has many advantages such as extraordinary multitasking skills, low energy consumption, and affordable prices. Thus, ESP32 is the right choice for those who want to create IoT projects at affordable prices.

2.2. Passive Infrared Receiver (PIR) sensors

PIR (Passive Infrared Receiver) sensor is a sensor that is commonly used to detect the presence of humans. This application is commonly used for alarm systems in homes or offices. PIR sensor is a sensor that captures infrared signal emissions emitted by the human body or animals. PIR sensor can respond to changes in infrared signal emissions emitted by the human body [37]. Room conditions with changes in temperature in humans in a room become early values (set points) that are used as references in the control system. Changes in temperature in humans in the room are detected by the PIR Sensor. It is called PIR (Passive Infrared Receiver) because this sensor only identifies areas without any energy that must be emitted. PIR is a mixture of a pyroelectric crystal, a filter, and a Fresnel lens. This sensor is very sensitive to changes in temperature in humans.

2.3. Node-RED

Node-RED is a flow-based development platform for visually connecting hardware, APIs, and online services. Node-RED uses a web-based interface that makes it easy for users to create flows by connecting blocks or "nodes" using a drag-and-drop method. The platform is popular for Internet of Things (IoT) applications, home automation, and web service integration [38]–[40].

Key Features of Node-RED are

- Visual Development that offers graphical interface-based development, allowing users to create data flows without having to write complex code.
- Support for IoT: Node-RED is designed with a primary focus on IoT. You can connect IoT devices such as sensors, actuators, and other systems easily.
- Modularity with Nodes: Each function in the Node-RED workflow is represented by a node. These nodes cover many things, such as reading data from sensors, sending emails, processing data, etc.
- Open Source: Node-RED is an open-source project, so the developer community can contribute and extend its functionality by adding additional nodes.
- Integration with Other Platforms: Node-RED can be integrated with various platforms such as AWS, Azure, MQTT, HTTP, WebSocket, and many other API services.
- Runs on Various Devices: Node-RED can run on servers, desktop computers, or devices such as Raspberry Pi, making it very flexible to use in various environments.

Uses of Node-RED:

- Home Automation: Create a system to control smart home devices.
- IoT Integration: Connect IoT sensors and collect data from multiple sources.
- Real-Time Data Processing: Fetch data from external sources, such as APIs or databases, and process it directly.
- System Automation: Automate workflows on servers and in the cloud.

Application Examples:

- Energy Monitoring: Node-RED can be used to monitor the energy consumption of a home or building using sensors and provide reports or notifications.
- Office Automation: Create workflows to sync cloud services, such as Google Sheets, Dropbox, or email services.
- IoT Control: Connect and control IoT devices, such as smart lights, locks, or HVAC systems through visually structured logic flows.

Node-RED Advantages:

- Ease of Use: Users can easily create logic flows without requiring in-depth programming skills.
- Wide Compatibility: Node-RED supports a wide range of devices, protocols, and services.
- Extensibility: Many additional modules and nodes created by the community are available to integrate into projects.

2.3. Message Queuing Telemetry Transport (MQQT)

MQTT (Message Queuing Telemetry Transport) is a very lightweight and efficient communication protocol used to send and receive messages between devices, especially in Internet of Things (IoT) applications. MQTT is designed for low-power, low-bandwidth communication, making it an ideal choice for resource-constrained IoT devices. The protocol uses very little data overhead, making it suitable for devices with limited power, bandwidth, and computing capacity. MQTT uses a publish-subscribe communication model, where devices do not communicate directly with each other. Instead, they communicate through a broker that acts as an intermediary. MQTT allows devices to maintain persistent sessions, so that when a device disconnects from the network and then reconnects, important messages sent during the disconnection period can be delivered. MQTT allows devices to declare messages that will be sent by the broker if the device unexpectedly disconnects or fails. MQTT is a very effective communication protocol, especially in the IoT world where small devices, slow networks, and low power are very common. The flexibility of the publish-subscribe architecture, efficient bandwidth usage, and support for unstable networks make it one of the most widely used protocols in the IoT ecosystem.

2.4. Proposed Methods

The design is used to find out and understand about operating a prototype of public street lighting (PJU) by providing a PIR motion sensor based on Node Red that is integrated with a smartphone as a controller for the device. The design of public street lighting (PJU) uses a program on the Node-Red software that will be applied to the Node MCU Esp32. Programming on Node-Red on Arduino can automatically be controlled directly via a smartphone, because the Node MCU Esp8266 has a wifi module installed, so control can be done anywhere as long as there is an internet connection, and can also be connected to a smartphone. Public street lighting uses a passive infrared receiver (PIR) sensor which is the author's final project model that requires a control circuit and Node-red as a command to drive this tool via wifi communication, from this various experiments to determine the sensor response with reference to the sensitivity distance of the PIR (Passive Infrared Reciver) sensor to the movement and the resulting comparison current When given a load on public street lighting based on Nod-Red with an ampere clamp on the PZEM-004T sensor. Figure 2 is Flowchart for Making Tools

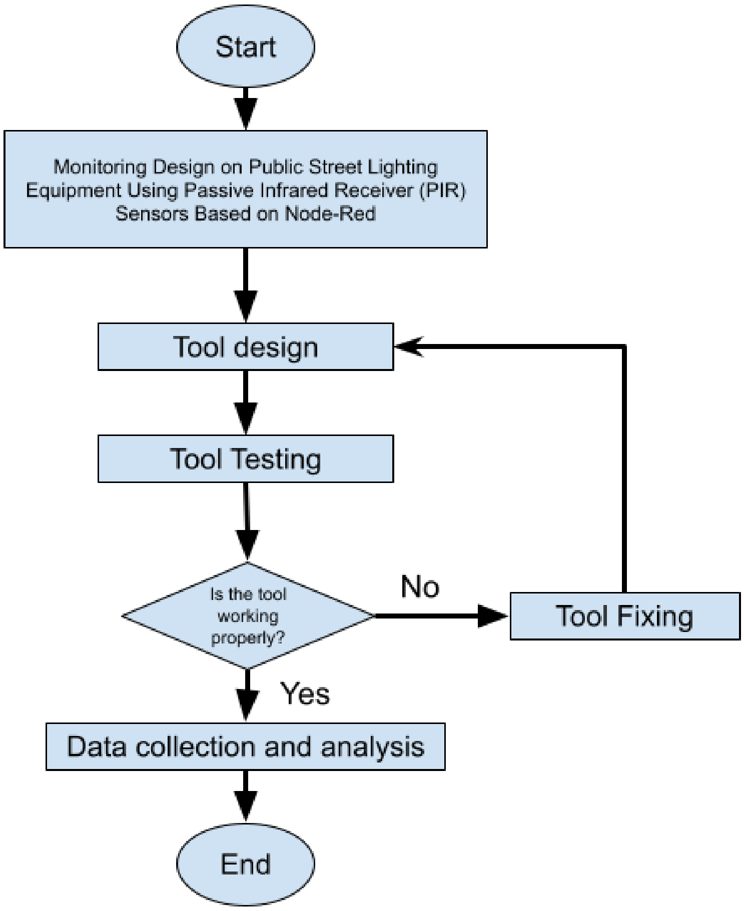

Figure 2 Flowchart for Making Tools

The design of the wiring of the components is made so that the results between the design and manufacture of the Monitoring tool on the Public Street Lighting Equipment (PJU) Using the Node-Red Based Passive Infrared Receiver (PIR) Sensor are appropriate. It can be seen in Figure 3. Figure 4 is the photo of prototype

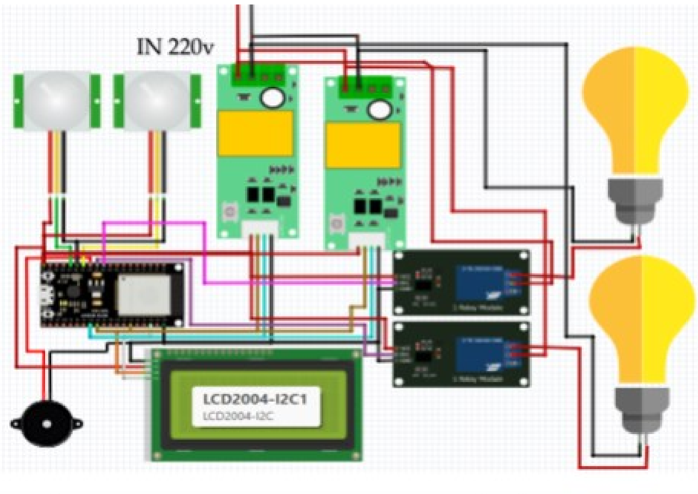

Figure 3 Design of monitoring wiring on public road lighting equipment using Node-Red based Passive Infrared Receiver Sensor.

Figure 4. Photo of the prototype

Public street lighting uses a passive infrared receiver (PIR) sensor which is the author's final project model that requires a control circuit and Node-red as a command to drive this tool via wifi communication, from this, various experiments to determine the sensor response with reference to the sensitivity distance of the PIR sensor (Passive Infrared Receiver) to the movement and comparison current that is produced when given a load on the Node-Red-based public street lighting (PJU) with a multimeter on the PZEM-004T sensor. This measurement and testing are carried out to determine each part of the Passive Infrared Receiver (PIR) sensor input, the PZEM-004T sensor, and the relay work according to their function. The test results will be entered into a table, after the test result data has been entered into the table, the next step is to find the current accuracy presentation. The results that have been obtained will be summarized in the current value presentation which can be seen in equation 1

$$\eta_A = \frac{Total\ of\ Current\ sensor - Total\ of\ Current\ Manual}{Manual\ Current} \quad (1)$$

3. RESULTS AND DISCUSSION

The sensitivity test on this sensor aims to determine the sensitivity of the sensor in detecting objects both at the closest and furthest distances to objects on public street lighting poles (PJU), where this sensor requires an input voltage of 5Vdc. This sensor will be placed on the part of the pole facing straight towards the object to detect objects passing through the sensor, the object to be detected in the test is a human using a hand as a substitute for a human object, where 10 trials were carried out at a distance of 1 to 10 meters and the following are the results of the PIR sensor sensitivity test on objects.

Table 1. Result of SensitivityTest

No	Distance (M)	PIR Sensor Position		Condition
		Front	Crooked	Dark
1	0.5	v	v	Detected
2	1	v	v	Detected
3	1.5	v	v	Detected
4	2	v	v	Detected
5	2.5	v	v	Detected
6	3	v	v	Detected
7	3.5	v	v	Detected
8	4	v	v	Detected
9	4.5	v	v	Detected
10	5	v	v	Detected
11	5.5	v	v	Detected
12	6	v	v	Detected
13	6.5	v	-	Detected
14	7	v	-	Detected
15	7.5	v	-	Detected
16	8	v	-	Detected
17	8.5	-	-	-

Based on the test results, it was found that the PIR sensor works when the human object is at a distance of 1 to 8 meters and can detect objects in bright conditions. PIR sensor testing is carried out to determine the maximum distance that can be reached when given a voltage of 5Vdc.

Table 2. Result of SensitivityTest

No	Distance (M)	PIR Sensor Position		Condition
		Front	Crooked	Dark
1	0.5	v	v	Detected
2	1	v	v	Detected
3	1.5	v	v	Detected
4	2	v	v	Detected
5	2.5	v	v	Detected
6	3	v	v	Detected
7	3.5	v	v	Detected
8	4	v	v	Detected
9	4.5	v	v	Detected
10	5	v	v	Detected
11	5.5	v	v	Detected
12	6	v	v	Detected
13	6.5	v	-	Detected
14	7	v	-	Detected
15	7.5	v	-	Detected
16	8	v	-	Detected
17	8.5	-	-	-

Sensor reading testing is the most important test compared to other parameter tests in the process of making this prototype. This test involves reading the current variable. Where when there is a current that is read, the condition of the lamp is in good condition. This test is carried out with 6 different load conditions so that the measured data is more varied, which will then be compared directly with conventional measuring instruments, namely with Tang Ampere.

Table 3. Sensor Reading Testing

No	Load	Current In Measuring Instruments (A)	Current On Prototype (A)
1	1 Lamp 3W	0.02	0.02
2	1 Lamp 4W	0.02	0.03
3	1 Lamp 5W	0.04	0.05
4	1 Lamp 7W	0.02	0.03
5	1 Lamp 9W	0.05	0.06
6	1 Lamp 15W	0.06	0.07
Total		0.021	0.026

From Table 3, it shows the results of current sensor testing with varying load conditions. From the description of the table above, it is known that the current accuracy presentation value is 0.24%. the greater the load given to the tool, the greater the current value read on the sensor and the current value tested manually. In Figure 5, there is a Node-red dashboard display that is ready to be used for monitoring on Public Street Lighting devices using Node-red-based Passive Infrared Receiver (PIR) sensors.

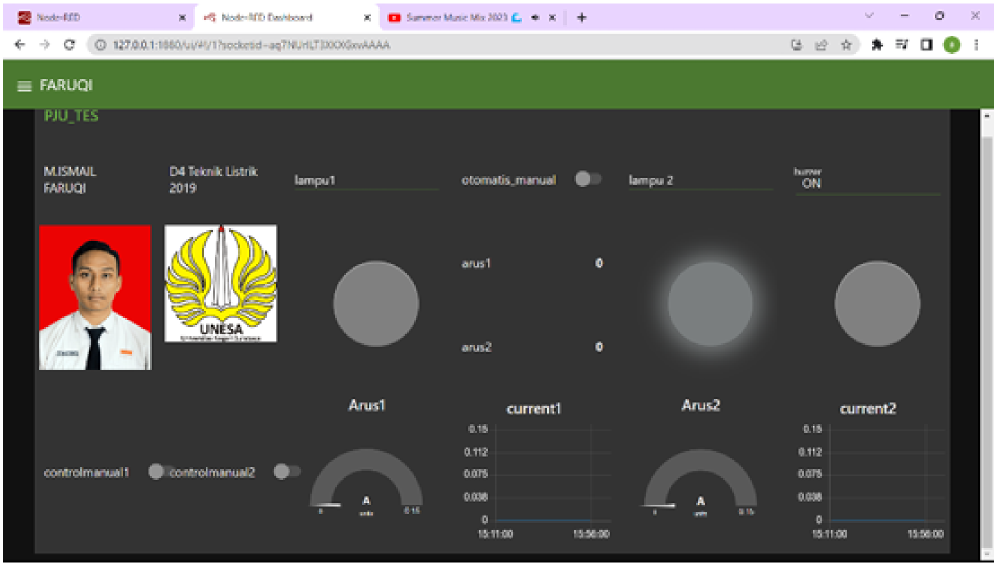

Figure 5. Monitoring on Node-red

4. CONCLUSION

Based on Test Results At a distance of 9 meters, the PIR sensor cannot detect Infrared signals because the PIR sensor has a maximum distance in detecting movement on an object of only 8 meters according to the tests that have been carried out. In designing a Monitoring system for Node-red-based street lighting (PJU), a PZEM004T sensor is needed which is used to monitor the results of current measurements and current can also be information when there is no load on the current, the lamp is off or damaged, which means the lamp must be replaced immediately, which is controlled via a smartphone using portable WiFi as an internet signal supplier connected to ESP 32 which is an open source IoT platform.

REFERENCES

[1] R. Juhász, M. P. Squicciarini, and N. Voigtländer, "Technology adoption and productivity growth: Evidence from industrialization in France," Journal of Political Economy, vol. 132, no. 10, pp. 3215–3259, 2024. doi: https://doi.org/10.1086/730205

[2] S. Braguinsky, A. Ohyama, T. Okazaki, T, C. Syverson, "Product Innovation, Product Diversification, and Firm Growth: Evidence from Japan's Early Industrialization", American Economic Review, vol. 111, no. 12, pp. 3795-3826, 2021. doi: https://doi.org/10.1257/aer.20201656

[3] E. BrynjolfssonD. Rock, C. Syverson, " The Productivity J-Curve: How Intangibles Complement General Purpose Technologie", American Economic Journal: Macroeconomics, vol 13, no. 1, pp. 333-372, 2021. doi: https://doi.org/10.1257/mac.20180386.

[4] H. Alofaysan, M. Radulescu, D. Balsalobre-Lorente, and K. S. Mohammed, "The effect of eco-friendly and financial technologies on renewable energy growth in emerging economies," Heliyon, vol. 10, no. 17, 2024. doi: https://doi.org/10.1016/j.heliyon.2024.e36641.

[5] C. Yang, Z.Wu, X. Li, A. Franz, " Risk-constrained stochastic scheduling for energy hub: Integrating renewables, demand response, and electric vehicles", Energy, vol. 288, 2024. doi: https://doi.org/10.1016/j.energy.2023.129680

[6] P. Onu, A. Pradhan, C. Mbohwa, "The potential of industry 4.0 for renewable energy and materials development – The case of multinational energy companies", Heliyon, vol. 9, no. 10, 2023. doi: https://doi.org/10.1016/j.heliyon.2023.e20547.

[7] J.E. Garzón Baquero, D. Bellon Monsalve, " From fossil fuel energy to hydrogen energy: Transformation of fossil fuel energy economies into hydrogen economies through social entrepreneurship", International Journal of Hydrogen Energy, vol. 54, pp. 574-585, 2024. doi: https://doi.org/10.1016/j.ijhydene.2023.06.123

[8] H. Alofaysan, M. Radulescu, D. Balsalobre-Lorente, and K. S. Mohammed, "The effect of eco-friendly and financial technologies on renewable energy growth in emerging economies," Heliyon, vol. 10, no. 17, 2024. doi: https://doi.org/10.1016/j.heliyon.2024.e36641.

[9] C. Yang, Z.Wu, X. Li, A. Franz, " Risk-constrained stochastic scheduling for energy hub: Integrating renewables, demand response, and electric vehicles", Energy, vol. 288, 2024. doi: https://doi.org/10.1016/j.energy.2023.129680.

[10] H. Tian, K, Wang, X. Cui, Z. Chen, E. Zhao, S. Saeedi, " Multi-objective planning of microgrid based on renewable energy sources and energy storage system", Journal of energy storage, vol. 68, 2023. doi : https://doi.org/10.1016/j.est.2023.107803.

[11] E. M. Ahmed and K. E. Elfaki, "Green technological progress implications on long-run sustainable economic growth," Journal of Knowledge Economy, vol. 15, no. 2, pp. 6860–6877, 2024. doi: https://doi.org/10.1007/s13132-023-01268-y

[12] E.M Ahmed, "Big Data Analytics Implications on Central Banking Green Technological Progress", International Journal of Information Technology and Desion Making, vol. 23. no.5, pp. 2065-2087. doi: https://doi.org/10.1142/S0219622023500669

[13] F.J. Hasanov, S. Mukhtarov, E. Suleymanov, S. Shannak," The role of renewable energy and total factor productivity in reducing carbon emissions: A case of top-ranked nations in the renewable energy country attractiveness index", vol. 361, 2024. doi : https://doi.org/10.1016/j.jenvman.2024.121220.

[14] H. Noh, K. Kang, and Y. Seo, "Environmental and energy efficiency assessments of offshore hydrogen supply chains utilizing compressed gaseous hydrogen, liquefied hydrogen, liquid organic hydrogen carriers and ammonia," International Journal of Hydrogen Energy, vol. 48, no. 20, pp. 7515–7532, 2023. doi: https://doi.org/10.1016/j.ijhydene.2022.11.085.

[15] W. Jin, D. Formiga Lopez, E. Heuvelink, and L. F. M. Marcelis, "Light use efficiency of lettuce cultivation in vertical farms compared with greenhouse and field," Food and Energy Security., vol. 12, no. 1, p. e391, 2023. doi: https://doi.org/110.1002/fes3.391

[16] M. A. Hasany, "Industrial Internet of Things for industry 4.0", Intelligent and Sustainable Engineering Systems for Industry 4.0 and Beyond, pp. 59-70, 2025. doi: https://doi.org/10.1201/9781003511298-3.

[17] A. Seeboo, " Logistic management and Industry 4.0: Within the construction industry", Intelligent and Sustainable Engineering Systems for Industry 4.0 and Beyond, pp. 164-179, 2025. doi: https://doi.org/10.1201/9781003511298-9.

[18] S.M. Saranya, D.Komarasamy, S. Mohanapriya, M. Iyapparaja, R.Prabavathi," Industry 4.0: The Role of Industrial IoT, Big Data, AR/VR, and Blockchain in the Digital Transformation, vol. 1172, pp. 11-39, 2025. doi: https://doi.org/10.1007/978-981-97-7494-4_2.

[19] U. Tariq, I. Ahmed, A. K. Bashir, and K. Shaukat, "A critical cybersecurity analysis and future research directions for the internet of things: a comprehensive review," Sensors, vol. 23, no. 8, p. 4117, 2023. doi: https://doi.org/10.3390/s23084117.

[20] O.S. Albahri, A.H. Alamoodi, " Cybersecurity and Artificial Intelligence Applications: A Bibliometric Analysis Based on Scopus Database", Mesopotamian Journal of CyberSecurity, vol. 2023, pp. 158-169, 2023. doi: https://doi.org/10.58496/MJCS/2023/018.

[21] M. Hossain, G. Kayas, R. Hasan, S. Noor, S.M.R Islam, " A Holistic Analysis of Internet of Things (IoT) Security: Principles, Practices, and New Perspectives", Future Internet, vol. 16, no.2, 2024. doi: https://doi.org/10.3390/fi16020040.

[22] R.Abreu, E. Simão, C. Serôdio, F. Branco, A.Valente, " Enhancing IoT Security in Vehicles: A Comprehensive Review of AI-Driven Solutions for Cyber-Threat Detection", AI (Switzerland), vol.5, no. 4, pp.2279-2299, 2024. doi: https://doi.org/10.3390/ai5040112.

[23] A. Haleem, M. Javaid, R.P Singh, " Encouraging Safety 4.0 to enhance industrial culture: An extensive study of its

technologies, roles, and challenges", Green Technologies and Sustainability, vol. 3, no. 3, 2024. doi: https://doi.org/10.1016/j.grets.2024.100158.

[24] A. Ghaffari, N. Jelodari, S. Pouralish, N. Derakhshanfard, B. Arasteh, "Securing internet of things using machine and deep learning methods: a survey", Cluster Computing, vol. 27, no. 7, pp. 9065-9089. doi: https://doi.org/10.1007/s10586-024-04509-0.

[25] X. Shu et al., " Triboelectric nanogenerators based self-powered visualized weight sensor with high accuracy and real time", Nano Energy, vo. 135, 2025.doi: https://doi.org/10.1016/j.nanoen.2024.110624.

[26] A. Salam, "Internet of things for sustainable community development: introduction and overview," Internet of Things pp. 1–31, 2024. doi: https://doi.org/10.1007/978-3-030-35291-2_1.

[27] M. Ali, P. Scandurra, F. Moretti, and H. H. R. Sherazi, "Anomaly detection in public street lighting data using unsupervised clustering," IEEE Transactions Consumer Electronics, vol. 70, no. 1, pp. 4524-4535, 2024. doi: https://doi.org/10.1109/TCE.2024.3354189.

[28] M. Thornbush and O. Golubchikov, "Street Lighting as a Dimension of Smart Energy Cities," Smart Cities, Energy Clim. Gov. Cities a Low-Carbon Futur., pp. 365–372, 2024. doi: https://doi.org/10.1002/9781118641156.ch21.

[29] P. Mohanty, U.C. Pati, K. Mahapatra, "EnSlight: Energy Autonomous LoRaWAN-Based, IoTEnabled, Real-Time Street Light Management System for Smart Cities and Smart Villages", Artificial Intelligence Techniques for Sustainable Development, pp. 114-139, 2024. doi: https://doi.org/10.1201/9781003546382-6.

[30] R. Hisab et al., "Cloud-Controlled Dynamic Smart Street Lighting System", International Conference on Next Generation Electronics, 2023. doi: https://doi.org/10.1109/NEleX59773.2023.10420861.

[31] M. Skula, D. Grzegorz, D. Vala, and V. Zelenková, "Multifunctional street lighting lamp," IFAC-PapersOnLine, vol. 58, no. 9, pp. 199–204, 2024. doi: https://doi.org/10.1016/j.ifacol.2024.07.396.

[32] K. Jaiswal, S. A. Ansar, A. K. Sharma, M. A. Sayeed, and N. Soni, "Implementing IoT for Energy-Efficient Smart Street Light Management," Lecture Notes in Networks and systems, vol. 1039, pp. 435–443, 2025. doi : https://doi.org/10.1007/978-981-97-4152-6_31.

[33] H. J. El-Khozondar et al., "A smart energy monitoring system using ESP32 microcontroller," e-Prime-Advances Electr. Eng. Electron. Energy, vol. 9, p. 100666, 2024. doi : https://doi.org/10.1016/j.prime.2024.100666.

[34] S. W. T. Al-Mashhadani, S. Kurnaz, " A Novel Function of a Research Process Based on a Power Internet of Things Architecture Intended for Smart Grid Demand Schemes", Applied Sciences (Switzerland), vol. 14, no. 13, 2024. doi : https://doi.org/10.3390/app14135799.

[35] R. H. Assaad, M. Mohammadi, O. Poudel, "Developing an intelligent IoT-enabled wearable multimodal biosensing device and cloud-based digital dashboard for real-time and comprehensive health, physiological, emotional, and cognitive monitoring using multi-sensor fusion technologies", Sensors and Actuators A: Physical, vol. 381, 2025. doi : https://doi.org/10.1016/j.sna.2024.116074

[36] C. J. Jobin, T. Jarin, V. Aarthi, and N. Raghavendran, "Cloud Computing's IoT based ThingSpeak, NodeMCU for Weather Monitoring," 5th International Conference on Electronics and Sustainable Communication Systems (ICESC), pp. 657–662, 2024. doi : https://doi.org/10.1109/ICESC60852.2024.10689978.

[37] Z. T. Mim, G. Sinha, and M. T. Hossain, "Passive Infrared Sensor Based Smart Elevator System to Save Electricity and Maximize Time Efficiency," 2024 2nd International Conference on Sustainable Computing and Smart Systems (ICSCSS), pp. 205–210, 2024. doi : https://doi.org/10.1109/ICSCSS60660.2024.10624830.

[38] C.Y. Chen, S.H. Wu, B.W. Huang, C.H. Huang, and C.F. Yang, "Web-based Internet of Things on environmental and lighting control and monitoring system using node-RED, MQTT and Modbus communications within embedded Linux platform," Internet of Things, vol. 27, p. 101305, 2024. doi : https://doi.org/10.1016/j.iot.2024.101305.

[39] L. Thomas, M. K. MV, S. D. SL, and P. BS, "Towards Comprehensive Home Automation: Leveraging the IoT, Node-RED, and Wireless Sensor Networks for Enhanced Control and Connectivity," Engineering Proceedings, vol. 59, no. 1, p. 173, 2024. doi : https://doi.org/10.3390/engproc2023059173.

[40] A. Rizzardi et al., "RailRED: a Node-RED-based framework for modeling Train Control Management Systems", International Conference on Wireless and Mobile Computing, Networking and Communications, pp. 671-674, 2024. doi : https://doi.org/10.1109/WiMob61911.2024.10770345.

.

BIOGRAPHIES OF AUTHORS

	**Muhammad Ismail Faruqi** is a active student of D4 Electrical Engineering study program, State University of Surabaya. research fields of monitoring tools, microcontrollers, renewable energy, data analysis, software engineering.
	**Dimas Herjuno** is a doctoral student in the Department of Life Science and Systems Engineering at Kyushu Institute of Technology. He received his B.Sc.in Electronics Engineering from Sepuluh Nopember Institute of Technology, Surabaya, in 2012 and his M.Sc. in Electronics Engineering from National Taiwan University of Science and Technology in 2017. His main research areas are embedded systems, computer vision and artificial intelligence. He can be contacted by email at herjuno.dimas478@mail.kyutech.jp