Journal of Applied Informatics Research
Fakultas Vokasi, Kampus Unesa 1, Ketintang, Surabaya, Indonesia
Website: https://journal.unesa.ac.id/index.php/jair/ | E-mail: jair@unesa.ac.id

# Designing an Internet of Things-Based Fire and Gas Leak Detection System

**M Adamu Islam Mashuri[1], Binti Kholifah[2], Faris Abdi El Hakim[3]**

[1,2,3]Department of Informatics Management, Universitas Negeri Surabaya, Indonesia
[1]mmashuri@unesa.ac.id, [2]bintikholifah@unesa.ac.id, [3]farishakim@unesa.ac.id

**ARTICLE INFORMATION**

**Article history:**

Received July 22, 2025
Revised July 24, 2025
Accepted July 25, 2025

***Keywords:***

LPG;
Leaks;
MQ-2;
Detection;
IoT

***ABSTRACT***

LPG currently plays a crucial role in daily human activities, both in households and industries. However, gas leaks from LPG cylinders have often led to fire incidents, primarily due to undetected gas emissions. To address this issue, a real-time gas and smoke detection system has been developed using the MQ-2 gas sensor and the ESP32 microcontroller. The system is designed to monitor gas concentration levels and provide early warnings through the Blynk application on smartphones, utilizing the Internet of Things (IoT) concept. The system can detect dangerous gas concentrations above 80 ppm and responds by activating a buzzer and LED indicators. In addition, warning notifications are sent to the user's smartphone. Test results show the system can accurately detect gas within a 10 cm radius of the sensor, with wireless notification capabilities reaching up to 500 meters. The system proves to be effective in enhancing safety and minimizing fire risks caused by undetected LPG leaks.

## 1. INTRODUCTION

Liquefied Petroleum Gas (LPG) is one of the most used energy sources in everyday life, both in households and industry, due to its efficiency and ease of storage and distribution [1], [2]. However, LPG's flammable and explosive nature makes it extremely dangerous if a leak goes undetected. In recent years, numerous fires and explosions have been reported due to LPG leaks, particularly in residential areas [3], [4].

Conventional methods that rely on human smell for the compound ethyl mercaptan as an odor marker in LPG are often ineffective. This is especially true when individuals are sleeping, have a smell disorder, or are not present at the scene [5]. Therefore, the development of an automatic gas detection system based on sensors and communication technology is an urgent need.

Semiconductor-based gas sensors, such as the MQ-2 sensor, have been widely used to detect flammable gases such as methane, butane, propane, and smoke [6]. These sensors work by detecting changes in resistance caused by the presence of certain gases in the air. On the other hand, the use of microcontrollers such as the ESP32 equipped with Wi-Fi connectivity enables the development of Internet of Things (IoT) based gas detection systems [7], [8].

The Internet of Things (IoT) has opened significant opportunities for building efficient, flexible, and remotely accessible monitoring systems. In the context of gas leak detection, IoT enables the integration of sensors, data processing systems, and user interfaces through mobile applications such as Blynk [9]. When a certain gas concentration threshold is exceeded, the system activates a buzzer, illuminates an indicator LED, and simultaneously sends an alert to the user's smartphone [10].

Numerous international studies have demonstrated the effectiveness of IoT-based gas detection systems in preventing fatal accidents in homes and industrial facilities [11], [12], [13]. Such systems not only increase user safety awareness but can also be implemented economically on a household scale [14], [15].

This research aims to design and test an LPG gas and smoke leak detection system based on an MQ-2 sensor and an ESP32 microcontroller, with remote notification via the Blynk application. With this design, the system is expected to provide real-time early warnings and minimize the risk of fires caused by undetected gas leaks. Gas leak monitoring systems based on the Internet of Things (IoT) have been widely implemented in various studies as an early detection effort and for real-time information transmission [16].

## 2. RESEARCH METHODS

This research methodology is designed to develop and test an Internet of Things (IoT)-based LPG gas leak detection system that integrates gas sensors, microcontrollers, and cloud-based software. This research uses an experimental engineering approach, namely by designing hardware and software, implementing them, and testing the system's functionality in real-world conditions. This method is in accordance with the approach used in various similar studies in the field of embedded systems and smart homes [17], [18].

### 2.1. System Design

This research uses a systems engineering approach to design and implement an LPG gas leak detector based on an MQ-2 sensor and an ESP32 microcontroller. The system is designed to detect gas concentrations in real time and provide early warnings via an LED, buzzer, and the Blynk application connected to a smartphone via Wi-Fi [19].

The system consists of two main parts:

- Hardware Design
- Software Design

#### 2.1.1. Hardware Design

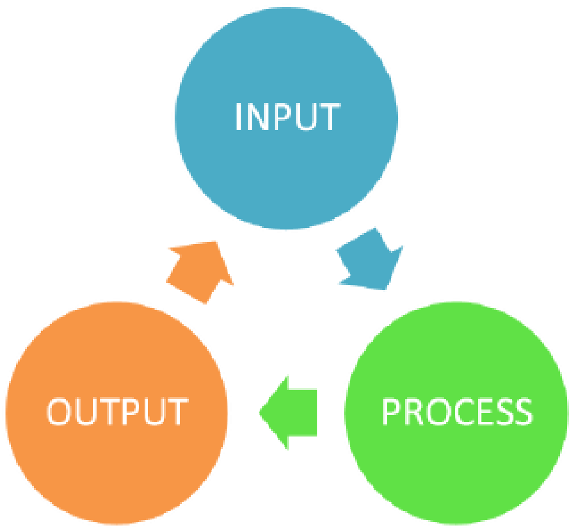


Figure 1. how the tool works

The hardware design in this study includes three main components: an input unit, a processing unit (controller), and an output unit. The input unit uses an MQ-2 gas sensor to detect gas concentrations in the air, such as LPG, methane, butane, and smoke. This sensor outputs an analog signal based on the detected gas levels in the environment.

For the processing unit, the system uses an ESP32 microcontroller module, which has both computing and wireless communication capabilities. The ESP32 processes signals from the MQ-2 sensor, converts them from analog to digital using an ADC (Analog to Digital Converter), and determines system actions based on predetermined threshold values.

The output unit uses an LED indicator and a buzzer as direct warnings. The LED will flash a certain number of times to indicate the danger level (normal, alert, or danger), while the buzzer will activate if the gas concentration exceeds a certain threshold. Furthermore, the ESP32 also sends sensor data in real time to the Blynk app installed on the user's smartphone via a Wi-Fi connection. This way, users can monitor gas conditions remotely.

The system block diagram can be seen in Figure 2. Based on the diagram, the MQ-2 sensor reads the gas concentration value in the form of an analog signal, which is then converted into a digital signal by the ESP32. The digital data is processed to determine whether the system needs to activate the LED and buzzer. In parallel, the data is also sent via the internet to the Blynk application for real-time display. With this approach, the system is not only able to provide local alerts via the LED and buzzer but can also provide remote information efficiently.

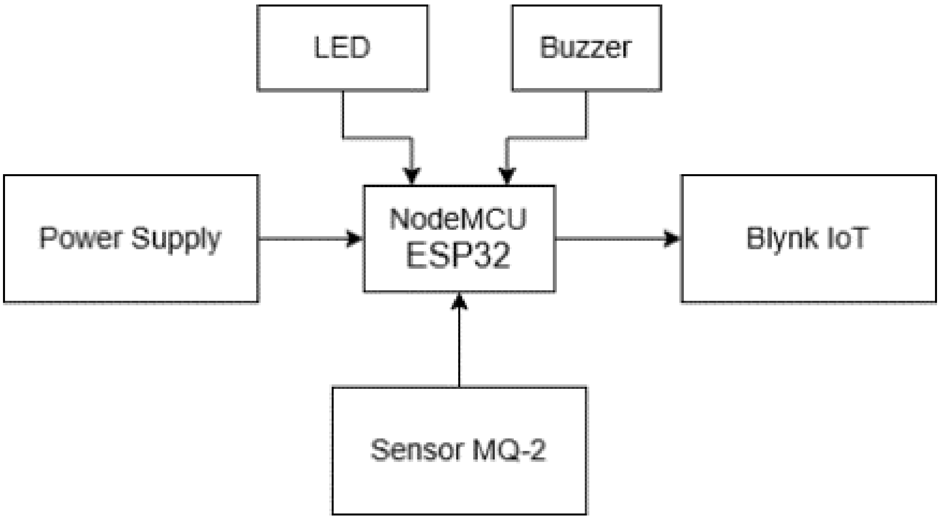


Figure 2. Block Diagram

This system circuit consists of an MQ-2 sensor circuit, an ESP32 microcontroller, LED indicators, a buzzer, and a connection to the Blynk platform. The ESP32 acts as the central controller, determining when the system should issue a warning, both physically and digitally. Figure 3 shows the overall circuit configuration.

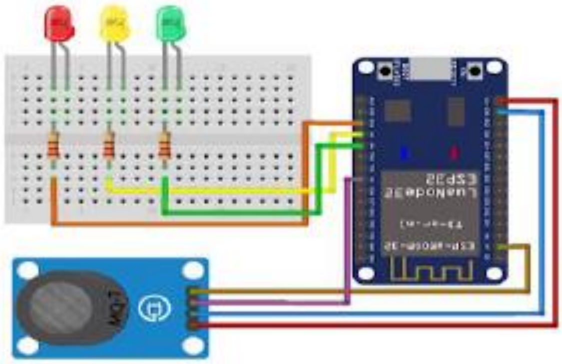

Figure 3. Hardware Design

Figure 3 shows the architecture of the designed LPG gas leak detection system, where the NodeMCU (in this case using the ESP32) acts as the central controller, managing communication between the input and output components. The NodeMCU receives input from the gas detection sensor (input), processes the data, and then responds through several output components.

The input and output circuits connected to the NodeMCU are detailed in Table 1, which includes the signal type (analog or digital), the function of each pin, and its role in the system. The input component is an MQ-2 gas sensor, which generates an analog signal based on the gas concentration in the air. Meanwhile, the output components consist of an LED indicator, a buzzer, and a Wi-Fi connection to send data to the Blynk application.

This structure ensures that the entire process—from gas detection and logical decision-making by the microcontroller, to visual and audible alerts and remote notification delivery—can be performed automatically and efficiently by the system.

Table 1. Device Input Output

| Pin NodeMCU ESP32 | Device |
|---|---|
| D33 | Sensor MQ-2 |
| D2, D4, D19 | LED1, LED2, LED3 |
| D21 | Buzzer |

### 2.1.2. Software Design

The software was developed using the Arduino IDE in C++. The main program reads data from the MQ-2 sensor, converts it to ppm, and then evaluates the hazard level based on a threshold. If the gas concentration exceeds the threshold, the system will issue an alert via a buzzer, LED, and notification to the Blynk app.

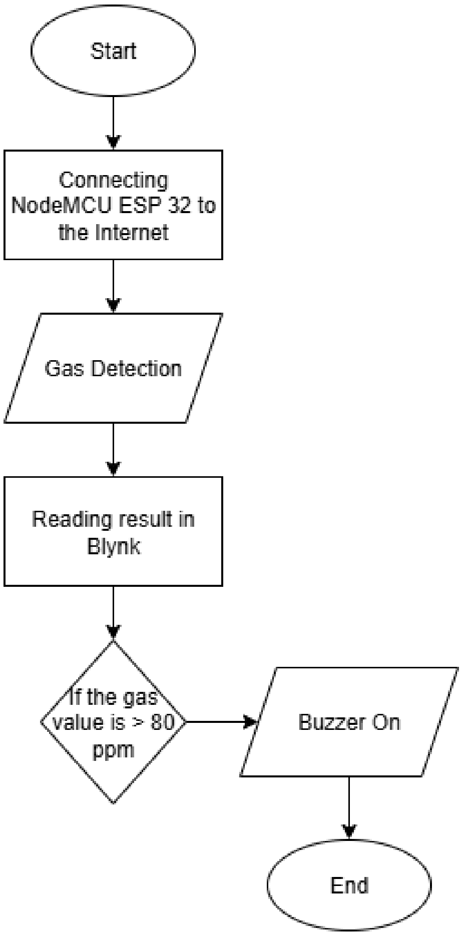


Figure 4. System Flowchart

The system begins when the NodeMCU ESP32 is supplied with input voltage and automatically initializes a connection to the internet via Wi-Fi. Once successfully connected to the network, the MQ-2 gas sensor activates and begins detecting the presence of flammable gases, such as LPG, in the surrounding environment.

The gas concentration detected by the MQ-2 sensor is then sent to the ESP32 microcontroller for processing. The microcontroller converts the analog signal from the sensor into a digital value and displays it on the LCD screen and the Blynk app on the user's smartphone. This data is used as a reference for determining safety conditions.

If the detected gas concentration value exceeds the threshold of 80 ppm, the system will:

- Sends an automatic notification to the Blynk application on the smartphone, stating that an LPG gas leak has been detected.
- Activates the buzzer as an audible alarm.
- Illuminates the LED as a visual hazard indicator.

However, if the gas value is still below the threshold, the system will only continue to display monitoring data without providing a warning.

## 3. RESULT AND DISCUSSION

Testing is conducted to evaluate the system's sensitivity, reliability, and effectiveness. Some aspects tested include:

### 3.1. Sensor response to LPG gas concentration versus distance.

The MQ-2 sensor was tested at distances between 1 and 10 cm from the LPG gas source. Results showed that the sensor had the highest sensitivity at distances of 1–5 cm, with a fast response and a significant increase in detected gas concentration values with increasing distance. At distances greater than 8 cm, readings began to become unstable, and sensitivity decreased. This is due to gas dispersion in the open air, which affects the sensor's accuracy in detecting gas concentrations at longer distances. The test can be seen in Figure 5, and the test results can be seen in Table 2.

Table 2. MQ-2 Sensor Test Results Based on Distance to LPG Gas Source

| Distance (cm) | Sensor value (PPM) | Description |
|---|---|---|
| 1 | 870 | Danger |
| 2 | 810 | Danger |
| 3 | 765 | Danger |
| 4 | 700 | Medium |
| 5 | 645 | Medium |
| 6 | 580 | Medium |
| 7 | 505 | Medium |
| 8 | 430 | Low |
| 9 | 370 | Low |
| 10 | 310 | Low |

From the results shown in Table 2, it can be concluded that the MQ-2 sensor response gradually decreases as the distance between the sensor and the gas source increases. In addition to the decrease in value, there was also instability in the readings at distances above 8 cm, indicating the sensor's effective operating limits under these test conditions. This finding is important as a basis for optimal sensor placement in real-world applications.

Figure 5. Distance Testing

### 3.2. MQ-2 Sensor Testing

To evaluate the accuracy of the MQ-2 sensor readings, we compared the LPG gas concentration values measured by the MQ-2-based prototype device with those of a factory-made gas detector (as a reference standard). The comparison was performed in parts per million (PPM) across several experimental scenarios in a confined space with a controlled gas volume.

The formula for calculating the percentage error is as follows:

$$Percentage\ Error = \left(\frac{MQ2\ Value - Factory\ Instrument\ Value}{Factory\ Instrument\ Value}\right) \times 100\% \quad (1)$$

The following table shows the measurement results and error calculations:

Table 3. MQ-2 Sensor Testing

| No | Gas Distance (cm) | Factory Instrument Value (PPM) | MQ-2 Value (PPM) | Error (%) |
|---|---|---|---|---|
| 1 | 1 | 920 | 885 | 8.33% |
| 2 | 3 | 900 | 870 | 7.50% |
| 3 | 5 | 860 | 835 | 6.94% |
| 4 | 7 | 810 | 795 | 4.84% |
| 5 | 10 | 760 | 740 | 7.69% |
| Average | | | | 7.06% |

From five tests at different distances, the average percentage error was 7.06%. This value is within the general tolerance limits for uncalibrated industrial prototype systems, which are generally permitted up to ±10% on a household or educational scale.

These results indicate that the MQ-2 sensor can produce nearly accurate readings when properly calibrated, although there are still slight deviations compared to the factory-made device. These differences can be caused by environmental factors (humidity, temperature), the initial sensor calibration, and the sensor's age.

### 3.3. IoT Testing

Internet of Things (IoT) system testing was conducted to ensure that gas sensor readings from the ESP32 microcontroller could be transmitted and displayed in real time via the Blynk app on a smartphone. This testing aimed to evaluate the accuracy of the data display and the stability of the Wi-Fi connection in transmitting information.

The MQ-2 sensor reads LPG gas concentration, and the resulting data is sent directly to the Blynk app via Wi-Fi. To ensure data accuracy, a comparison was made between the values displayed in the Arduino IDE Serial Monitor and those displayed on the Blynk app dashboard. Test results showed that the data displayed in Blynk was identical to the data on the Arduino, with no significant delays. Real-time data transmission from microcontrollers to cloud-based monitoring platforms such as Blynk or MQTT has been proven effective in several prior studies [20].

The system does not feature automatic push notifications when gas exceeds a threshold, but visual monitoring can still be performed through the regularly updated gas value display in Blynk. This demonstrates that the system can provide sufficient information to users to act in the event of a gas leak, even without a notification-based alarm.

Table 4. Testing Sensor Data Delivery to Blynk Application

| No | Gas Value (Serial Monitor) | Gas Value (Blynk App) | Value Difference | Delay Time (seconds) | Sync Status |
|---|---|---|---|---|---|
| 1 | 435 | 435 | 0 | 0.2 | synchronous |
| 2 | 470 | 470 | 0 | 0.3 | synchronous |
| 3 | 510 | 510 | 0 | 0.2 | synchronous |
| 4 | 390 | 390 | 0 | 0.1 | synchronous |
| 5 | 580 | 580 | 0 | 0.2 | synchronous |

From the results in Table 3, all gas values read in the Serial Monitor are identical to those displayed in the Blynk app, with no discrepancies and an average delay of only 0.2 seconds. This indicates that the system successfully transmits data in real time and stably over a Wi-Fi connection.

Although the system lacks automatic notification features when gas levels exceed thresholds, the ability to monitor gas levels directly through the Blynk app is sufficiently informative for users. Thus, the designed system has proven functional as an IoT-based remote gas monitoring tool.

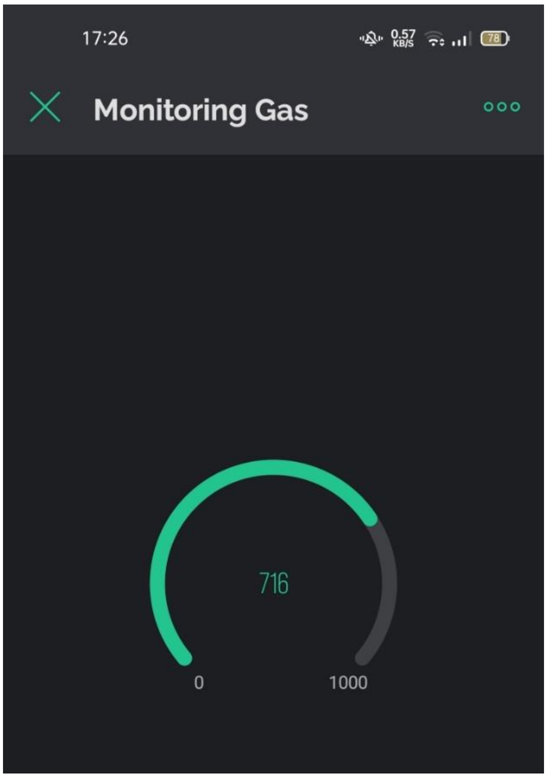

Figure 6. Smartphone display

Figure 6 shows the Blynk app on a smartphone. This display displays the gas readings from the MQ-2 sensor in real-time as a gauge (circular meter). This application allows users to monitor LPG levels remotely via an internet connection, allowing them to directly monitor environmental conditions using their mobile phone.

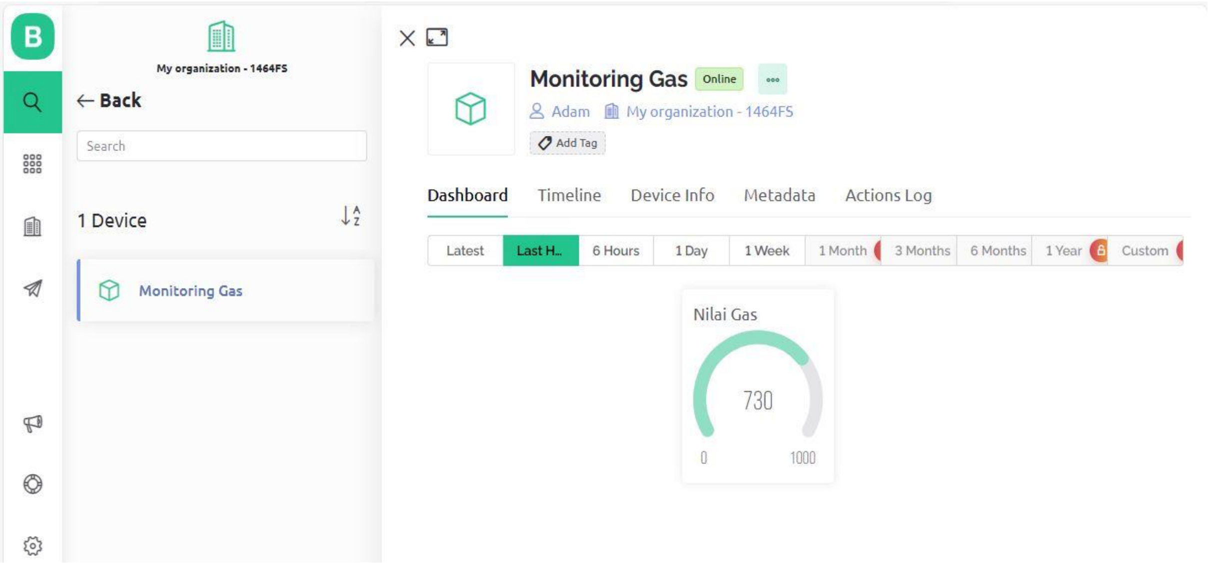

Figure 7. Blynk web display

Figure 7 shows the web version of the Blynk dashboard, accessed through a browser. In this display, users can also view the gas values detected by the sensor in real-time. Additionally, the web dashboard provides additional features such as data history, device information, and more comprehensive device management, suitable for both technical use and long-term monitoring.

## 4. CONCLUSION

This research successfully designed and implemented an Internet of Things (IoT)-based LPG gas leak detection system using an MQ-2 sensor and an ESP32 microcontroller. This system is capable of reading gas concentrations in real time and displaying data via the Blynk smartphone app, as well as providing alerts via LED and buzzer activation.

Test results showed that the MQ-2 sensor had the best sensitivity at 1–5 cm from the gas source, with stable readings and a fast response. Compared with a factory-made detection device, the system's accuracy yielded an average error of 7.06%, which is still within the tolerance range for a prototype-based monitoring system.

The system was also capable of synchronously transmitting data from the microcontroller to the Blynk app, with an average delay of only 0.2 seconds. This demonstrates that the system can reliably monitor gas levels in real time over a Wi-Fi network.

With the ability to accurately read gas data and display it via an IoT platform, this system is considered effective in detecting gas leaks and has potential for application in household and small-scale industrial environments.

## ACKNOWLEDGEMENTS

The author would like to thank all parties who supported this research. In particular, he would like to express his appreciation to Surabaya State University, specifically the Faculty of Vocational Studies and the Diploma 4 Informatics Management Study Program, for the facilities provided during the system design and testing process.

He would also like to thank his fellow lecturers, particularly Binti Kholifah and Faris Abdi El Hakim, who assisted in the preparation of this article. He hopes that the results of this research will positively contribute to the development of IoT-based gas detection systems in the future.

## REFERENCES

[1] D. Balogun et al., "LPG Smart Guard: An IoT-Based Solution for Real-Time Gas Cylinder Monitoring and Safety in Smart Homes," Engineering Proceedings, vol. 82, no. 1, p. 9, 2024, https://doi.org/10.3390/ecsa-11-20471

[2] B. Jena, "LPG gas leakage detection system using IoT," Journal of Engineering Science and Technology, 2023, https://doi.org/10.1016/j.matpr.2022.11.172

[3] O. Flores-Cortez, R. Cortez, and B. González, "Design and Implementation of an IoT Based LPG and CO Gases Monitoring System," arXiv preprint, 2021, https://doi.org/10.48550/arXiv.2107.07406

[4] Mas Guieta Aton et al., "Development of LPG Gas Leakage Detection using ESP32," International Journal of Research and Innovation Management, vol. 8, no. 1, 2022

[5] T. Hötting, A. Heimann, and H. Laakso, "The perception of odor is not a surrogate marker for chemical exposure: A review of factors influencing human odor perception," *Toxicology and Applied Pharmacology*, vol. 266, no. 2, pp. 109–117, 2013 https://doi.org/10.1016/j.taap.2012.12.011

[6] Ram Prasad, "Microcontroller Based AVR Hazardous Gas Detection System using IoT," arXiv preprint, 2023, https://doi.org/10.48550/arXiv.2305.12855

[7] M. Vijayalakshmi, K. B. Ramesh, and S. PG, "IoT-Enabled LPG Leakage Monitoring with Arduino Uno, ESP32, and Real-Time Mobile Alerts via Flutter," Proceedings ICOFE-2024, Jan. 2025, http://dx.doi.org/10.2139/ssrn.5088837

[8] F. Masud Foysal et al., "Integrated IoT-Based Smart Billing and LPG Gas Leakage Detection System for Energy Efficiency and Safety in Smart Living," Journal of Engineering Research and Reports, vol. 27, no. 1, pp. 1–15, 2025, https://doi.org/10.9734/jerr/2025/v27i11364

[9] Sudip Chakraborty et al., "Smart LPG Leakage Monitoring and Control System using Gas Sensor MQ-X, AWS IoT, and ESP Module," Int. J. Appl. Eng. Mgmt. Letters, vol. 8, no. 1, Feb. 2024, https://doi.org/10.5281/zenodo.10718875

[10] N. K. Jumaa, "IoT Based Gas Leakage Detection and Alarming System," *International Journal of Electrical and Electronics Engineering (IJEEE)*, vol. 18, no. 1, 2022, https://doi.org/10.37917/ijeee.18.1.8

[11] A. Okubanjo et al., "Real-Time LPG Leakage Monitoring System Using IoT and GSM," *Sigma Journal of Engineering and Natural Sciences*, vol. 43, no. 3, pp. 962–980, Jun. 2025, https://doi.org/10.14744/sigma.2025.00084

[12] Design of an LPG Leak Detection System using IoT Based MQ-2 Sensor," ResearchGate, Nov. 2024, https://doi.org/10.59934/jaiea.v3i1.337

[13] K. Paterya et al, "IoT-Based LPG Gas Leakage Detection and Prevention System," *IJARSCT*, vol. 4, no. 3, pp. –, Dec. 2024, https://doi.org/10.48175/568529

[14] L. Ilhamdi, M. Fikry, dan H. A. Kautsar Aidilof, "Smart Fire Prevention: An IoT Approach to Detecting LPG Leaks and Fire Hazards," *2nd International Conference on Multidisciplinary Engineering*, vol. 2, 2024, pp. 1–10,

[15] Parag Narkhede et al., "Gas Detection and Identification Using Multimodal Artificial Intelligence Based Sensor Fusion," *arXiv preprint*, 2021, https://doi.org/10.3390/asi4010003

[16] M. Iqbal Prananda, S. Syahputra, and M. A. Syari, "Design Of An LPG Leak Detection System Using IoT Based MQ-2 Sensor," Journal of Artificial Intelligence and Engineering Applications, vol. 3, no. 1, pp. 383–387, 2023, https://doi.org/10.59934/jaiea.v3i1.337

[17] A. Shaputra, T. Andriani, A. Jaya, dan N. Aryanto, "Design and Development of Internet of Thing (IoT)-Based LPG Gas Leak Detector with Automatic Valve Closing Using a Servo Motor," Altron: Journal of Electronics, Science & Energy Systems, vol. 2, no. 2, 2022, https://doi.org/10.51401/altron.v2i02.3107

[18] H. A. Wicsksono, R. O. Syahda, N. Syahid, dan I. P. Sary, "Liquid Petroleum Gas (LPG) Cylinder Leak Detection Tool Using MQ-2 Sensor Based on Internet of Things (IoT)," *Ultima Computing: Jurnal Sistem Komputer*, vol. 16, no. 2, pp. 46–55, 2024. https://doi.org/10.31937/sk.v16i2.3658
[19] R. K. Kodali and S. Soratkal, “MQTT based home automation system using ESP8266,” *2016 IEEE Region 10 Humanitarian Technology Conference (R10-HTC)*, pp. 1–5, 2016, https://doi.org/10.1109/R10-HTC.2016.7906845
[20] R. T. Kusumadewi, R. Kurniadi, and U. Y. Oktiawati, “Purwarupa Pendeteksi Liquified Petroleum Gas (LPG) Menggunakan Sensor MQ-2 dengan Blynk,” J. Listrik Instrum. Elektron. Terapan (JuLIET), vol. 3, no. 1, 2024, https://doi.org/10.22146/juliet.v3i1.74621

## AUTHOR BIOGRAPHY

| | |
|---|---|
|  | **M Adamu Islam Mashuri** is a lecturer at the Department of Informatics Management, Surabaya State University, Indonesia. He earned his Bachelor of Applied Engineering (S.Tr.T) from the Surabaya State Electronics Polytechnic (PENS) in Telecommunication Engineering, Surabaya in 2021. He also earned his Master of Applied Computer (M.Tr.Kom) from the Surabaya State Electronics Polytechnic (PENS) in Informatics and Computer Engineering, Surabaya in 2023. He mainly researches the Internet of Things and Artificial Intelligence. He can be contacted via email: mmashuri@unesa.ac.id. |
|  | **Binti Kholifah** is a lecturer in the Department of Informatics Management, Surabaya State University, Indonesia. She earned her Bachelor of Computer Science (S.Kom) from Maulana Malik Ibrahim State Islamic University in Informatics Engineering, Surabaya in 2019. She also earned her Master of Applied Computer Science (M.Tr.Kom) from Surabaya State Electronics Polytechnic (PENS) in Informatics and Computer Engineering, Surabaya in 2021. She primarily research Game Programming and Mobile Programming. She can be contacted via email: nodaholifah@unesa.ac.id. |
|  | **Faris Abdi El Hakim** is a lecturer at the Department of Informatics Management, Surabaya State University, Indonesia. He earned his Bachelor of Computer Science (S.Kom) from Brawijaya State University (UB) in Informatics Engineering, Surabaya in 2018. He also earned his Master of Applied Computer Science (M.Tr.Kom) from Surabaya State Electronics Polytechnic (PENS) in Informatics and Computer Engineering, Surabaya in 2023. He mainly researches Web Programming. He can be contacted via email: farishakim@unesa.ac.id. |