

# A Sensor-Based Gas Leakage Detection System for Kitchen Safety Using Arduino Uno R3

*Kristian Paul A. Alcala, Justine C. Alcance, Marvin T. Eclavea & Amiel S. Landicho*

Safety is a crucial concern in the modern world since accidents can occur anywhere. Areas that use flammable gases are especially prone to accidental fires. The advancement of futuristic technologies, such as the Internet of Things (IoT), enables the integration of devices and automation of daily tasks (Sokienah, 2023; Alahi et al., 2023; Choudhary, 2024; Zreikat et al., 2025; Rathi et al., 2025). In this study, IoT is applied as part of a gas detection system to identify leaks, alert users, and prevent further gas-related hazards. One hazardous gas widely employed in industry and detrimental to human health must be closely monitored; if its levels exceed the average range, the system ensures that immediate safety measures are taken (Márquez-Sánchez et al., 2023).

Gas leak detection systems are designed to prevent explosions by identifying leaks at an early stage. As science and technology advance, these systems continue to evolve and become more sophisticated. A commonly monitored gas is Liquefied Petroleum Gas (LPG), also known as butane, which is extensively used in both residential and commercial settings but

poses serious risks if mishandled. The use of detection systems is therefore essential for guaranteeing safety.

Several innovations have been developed to improve the effectiveness of such systems. For instance, unlike conventional gas detection devices, the LPG Gas Leakage Detection Control System by Bairagi et al. (2024) not only triggers an audible warning but also automatically turns off the gas valve when a leak is detected. This additional feature enhances safety by preventing further leakage and reducing the risk of accidents. Similarly, Faye et al. (2025) designed a system that employs an audible alarm to promptly notify users of a gas leak, enabling them to take immediate corrective measures and prevent potential disasters. Mishra et al. (2025) further emphasized the role of IoT by integrating detection systems with the Blynk Application, which provides real-time information about the type and concentration of gas detected. This ensures that users can easily interpret the data and respond effectively. The integration of Arduino technology provides additional advantages by simplifying the connection of sensors and components into a compact and user-friendly system (Ga et al., 2021; Gao et al., 2021; Sharipov et al., 2025). This design improves both efficiency and reliability, making the system more effective in everyday use. Researching gas leakage detectors also highlights the importance of adhering to safety regulations and understanding the dangers posed by gas leaks.

Gas leaks remain a global concern due to their potentially lethal consequences. They may occur when gas appliances such as stoves or heaters are not properly maintained, or when gas pipelines are damaged (Márquez-Sánchez et al., 2023). To address this issue, researchers have developed gas leakage detectors that utilize chemical, electrochemical, or physical sensors to detect the presence of specific gases or groups of gases.

Once a leak is detected, the system typically triggers alarms to warn nearby residents and may even notify designated personnel.

Preventive action is critical once a leak is identified. Turning off the gas supply before or alongside triggering an alert system minimizes further leakage and significantly reduces the risk of fire or explosion. Detection systems may then activate alarms through multiple channels, including audio alerts, visual indicators, or mobile notifications, ensuring that people are informed promptly. The use of Arduino Uno R3 further enhances system reliability, as it processes sensor data autonomously and activates appropriate responses without requiring manual input. This enables the system to sound alarms, enforce safety protocols, or shut off the gas supply, providing a dependable solution for enhancing safety, particularly in kitchens.

The main objective of this study is to design and demonstrate a sensor-based gas leakage detection system capable of locating LPG leaks under varying environmental conditions. The proposed system aims to detect, signal, and control gas leaks efficiently while providing users with timely alerts. At the core of this design is a sensor that can quickly and accurately identify gas leaks, thereby helping prevent accidents and safeguarding lives and property.

## **Theoretical Framework**

### *Gas*

Gas, an invisible state of matter, permeates the environment and plays a fundamental role in both natural and human-made phenomena. From the air people breathe to the stars in the night sky, gas is an ethereal entity that impacts daily lives. Safety is paramount in modern society, as

accidents involving gases can occur anywhere. Environments handling volatile and flammable gases pose a higher risk of accidental fires. Particular attention must be given to hazardous gases commonly used in industry due to their harmful effects on human health. Continuous monitoring of gas levels allows abnormal increases to be promptly detected, enabling timely safety interventions (Márquez-Sánchez et al., 2023).

LPG, commonly used as cooking gas, is a crucial resource in households and commercial settings. However, LPG use presents potential hazards. Accidental depletion during cooking or unnoticed gas leaks can lead to critical situations, including house fires.

### ***LPG Gas Leak***

Gas leaks are a leading cause of residential fires, resulting in property damage and potential loss of life (Brodsky et al., 2024). LPG leaks are often difficult to detect with the naked eye, and without detection systems, the risk of fire increases. According to the Bureau of Fire Protection (BFP) incident statistics, 492 fires in 2019 were caused by gas or oil stoves (BFP, 2019).

While LPG offers convenience, mishandling it can pose serious risks. Dedicated gas leak detection systems for LPG are therefore essential. Friday et al. (2025) and Subramanian et al. (2020) emphasize the importance of integrating sensors to detect LPG leaks and issue early warnings, such as SMS notifications, allowing affected parties to take preventive measures. Asafe et al. (2022) demonstrated a system using an embedded microcontroller and MQ-2 gas sensor to detect gas leaks and notify owners or service stations of potential hazards. Such systems have proven effective in alerting users promptly and preventing explosions.

### *Gas Leakage Prototype*

Hasibuan et al. (2019) developed a gas leak detection system that identifies gas leaks and prevents accidents, ensuring the safety of individuals and property. The system employs sensors to detect gases in residential and industrial settings. Upon detecting a leak, the system alerts users through audible alarms and may send SMS notifications. Preventive measures include activating alarms, turning on exhaust fans to mitigate gas accumulation, and automatically shutting off the main power source to reduce hazards.

Similar systems, such as the Design and Development of Kitchen Gas Leakage Detection and Automatic Gas Shut-Off System, detect leaks, notify users, and automatically shut off gas supplies to prevent accidents (Apeh et al., 2014). Kuruvilla et al. (2025) proposed an integrated sensor system capable of detecting LPG under varying environmental conditions, maintaining accuracy across different temperatures and humidity levels. Mishra et al. (2025) highlighted the effectiveness of using Arduino with gas sensors to monitor toxic gases such as butane and methane, providing users with precise readings through the Blynk application.

The LPG Gas Leakage Detection Control System developed by Bairagi et al. (2024) goes a step further by automatically shutting off the gas valve in addition to issuing audible alarms, significantly reducing risks. Shah et al. (2024) developed a system that primarily relies on audible alarms to alert users when leaks are detected. Overall, these advancements demonstrate the critical role of sensor-based systems in ensuring safety by detecting, notifying, and preventing gas-related hazards.

## **Research Framework**

This study employed a survey-based approach to evaluate the effectiveness of a sensor-based gas leakage detection system. A total of 205 respondents participated in the study. The sample size was determined using Slovin's formula, and questionnaires were distributed through a random sampling technique to ensure representative participation. The questionnaire was developed based on the ISO 25010 software quality standard, covering key aspects such as functional suitability, reliability, usability, performance efficiency, and maintainability. To analyze the collected data, the researchers applied the weighted mean formula, which allowed each component's relative importance to be quantified and an overall score to be calculated. This approach provided a comprehensive evaluation of the system's quality, offering quantitative insights into its performance according to ISO 25010 criteria.

Respondents answered each question using a four-point Likert scale with the categories: strongly agree, agree, disagree, and strongly disagree. Each response was assigned a corresponding value, and the resulting mean scores were interpreted according to predefined ranges to determine the evaluation outcomes. This methodology enabled a systematic assessment of the software's quality attributes, ensuring reliable and valid results for the study.

### ***Experimental Design***

The experimental design for evaluating gas leakage detectors involved creating controlled environments, such as a chamber or room, where gas leaks could be safely simulated and the performance of the detectors assessed. This process required selecting appropriate gas detection

technologies and defining the experiment's parameters and procedures.

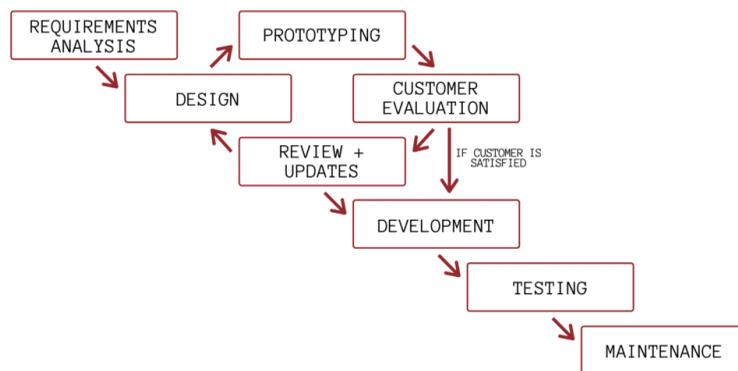
Researchers first determined which gases, such as methane or propane, would be used to test the sensitivity and accuracy of the detectors. The test chamber was then prepared, ensuring it was properly sealed and equipped with the necessary monitoring and measurement tools. Once the chamber was set up and the experimental guidelines were established, the tests commenced. Data collected during the experiments were analyzed to evaluate the detectors' sensitivity, accuracy, and overall performance.

The experimental design encompassed setting up controlled environments, selecting suitable gas detection technologies, establishing testing procedures, conducting experiments, and analyzing the results to determine the effectiveness of the gas leakage detectors.

### ***Modeling***

The models chosen had a significant influence on the testing process. They specified what, where, and when the anticipated testing would occur, guided regression testing, and helped determine the appropriate testing methodologies. For the proposed system, the researchers employed the prototype model during its development, as it was the most suitable strategy for iterative testing and refinement.

**Figure 1**  
*Prototyping model*



The prototyping model used for developing the sensor-based gas leakage detection system involved an iterative process of creating and refining the system through multiple prototype iterations. The initial prototype served as a proof of concept, demonstrating the system's core features and functionalities. Feedback and insights from testing the initial prototype informed subsequent iterations, leading to improvements and enhancements that addressed identified issues. This approach aligns with existing literature on software prototyping techniques, highlighting the benefits, challenges, and best practices associated with using prototypes (Khan, 2021).

### ***Procedures of the Different Phases***

The development of the gas leakage detection system followed several distinct phases under the prototyping model.

*Planning and design.* The planning and design phases began with identifying the research questions and specific objectives of the study. A literature review was conducted to understand the current state of knowledge, identify gaps, and determine areas requiring further research.

*Requirements analysis.* During the initial phase of the prototyping model, an extensive analysis of system requirements was conducted. This involved thoroughly examining the specifications and understanding the users' needs and expectations through effective communication. Researchers also assessed the availability and suitability of the required tools and materials for the project.

*Design.* In the design phase, an initial, rudimentary design of the gas leakage detector was created. This preliminary design was not fully detailed but served as a framework to provide users with a basic understanding of the system's functionality and structure.

*Prototyping.* The prototyping phase involved constructing a tangible, operational model of the system. Researchers acquired essential components such as the Arduino Uno R3 microcontroller, sensors, jumper wires, and a GSM module to build a working prototype. This allowed the team to evaluate and refine the system's design and functionality iteratively.

*Customer evaluation.* The prototype was presented to the client for initial evaluation. Feedback regarding strengths and weaknesses was collected and provided to the developers for improvements. If the client was satisfied with the prototype, the researchers proceeded directly to the development phase; otherwise, the review and update process was implemented.

*Review and updates.* When feedback indicated that the prototype required refinement, the researchers modified the system according to the client's suggestions. This iterative review ensured that user requirements were incorporated effectively before final development.

*Development.* In the development phase, the final working system was constructed to meet all identified requirements. The system was built, tested, and verified to ensure it performed as intended, incorporating all modifications suggested during the prototyping and evaluation phases.

*Testing.* The gas leakage detector underwent thorough testing to evaluate performance and identify potential errors. Minor flaws were corrected, and necessary adjustments were made to ensure the system operated reliably and met established standards.

*Maintenance.* After completing the final prototype, the fully developed system was deployed for operational use. Comprehensive evaluation ensured the system could accurately detect target gases, maintain sensor sensitivity and precision, and perform reliably under various conditions.

## Technical Framework

This section explains the various components of the prototype.

### *Software*

The software requirements for the proposed system are detailed in Table 1. These include the various programs necessary to develop a gas leakage detection system.

**Table 1**

*Software specification*

Software		Description
IDE Platform		contains a text editor for writing code, a message area, a text console, a toolbar with buttons for common functions and a series of menus.
Blynk Application		Blynk is an IoT platform for iOS or Android smartphones that is used to control Arduino, Internet.
Operating System		A Microsoft Windows operating system that runs on a 32-bit or 64-bit architecture used in the development of the system
Web browser		Chrome (recommended) or any web browser installed

The researchers used the IoT Blynk Application to interface with sensors and collect data, while an operating system managed hardware resources and provided a platform for other software components. Together, these software elements processed sensor data, facilitated decision-making, and allowed users to monitor and control the system. Additional software, such as a web browser or an Integrated Development Environment (IDE) for coding, was also required depending on the specific needs of the system.

**Table 2***Hardware specification*

Hardware	Specification
Arduino UNO 	microcontroller board based on the ATmega328P (datasheet) USB 2.0 Cable Type A/B
MQ-2 Sensor 	The MQ-135 gas sensor detects gases like smoke, alcohols, aromatic chemicals, ammonia, nitrogen, and oxygen.
GSM-Module 	The SIM800 offers all hardware interfaces between the module and customers' boards and contains 68 SMT pads.
Buzzer 	The Arduino buzzer is a device that produces sound when an electric current is passed through it.
NodeMCU ESP8266 	Amica NodeMCU measures 49mm x 26mm with a standard pin space of 0.1" between pins and 0.9" between rows.
Wood slices 	Wood slices used for prototype frame and main box.
Plastic cap 	Used for the closing mechanism for the lid of Gas tank
Handle Bar 	Used as a frame and handle for the plastic cap. Attachable to gas tank handle.

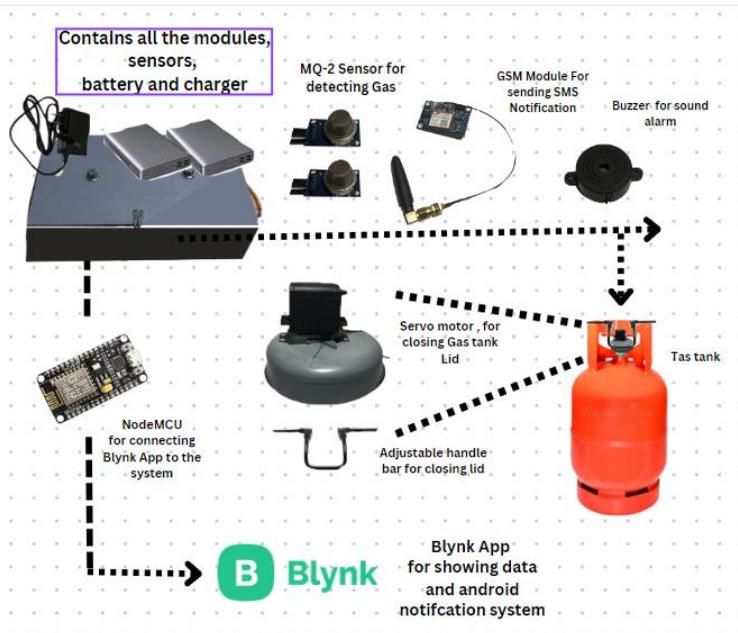
The hardware requirements for the gas leak detection system included several essential components. The researchers used sensors to detect the presence of gas, an Arduino microcontroller to process sensor data and make decisions, and the Blynk application to display the system's status. These components worked together to detect gas leaks and promptly alert users to any potential hazards.

## System Design

Figure 2 illustrates the process flow of the system. After completing the coding process, all sensors and modules were initialized while the system was in a connected state.

**Figure 2**

*System architecture*

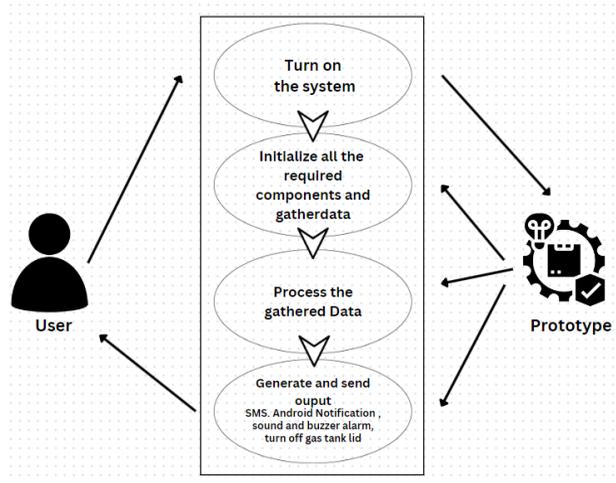


Following initialization, the sensors evaluated the environment based on predefined parameters. The microcontroller compared each sensor output against these parameters to determine whether the conditions were met. If a parameter exceeded the specified limits, the microcontroller activated the GSM module and triggered the buzzer to send an SMS alert indicating which parameter was breached. If the parameters were within acceptable ranges, the system continued to monitor the environment. Simultaneously, the IoT Blynk application displayed the current status of

the system.

**Figure 3**

*Use case diagram*



The Use Case diagram provided a comprehensive overview of the system's operation. During the implementation of the Sensor-Based Gas Leakage Detection System for Kitchen Safety using Arduino Uno R3, the user first installed and started the system. Once installed, the system automatically initialized all required sensors and components. It continuously monitored gas levels in the kitchen environment, collecting critical data. When a gas leak or abnormal gas level was detected, the system communicated the information to the user through multiple channels, including SMS notifications to mobile phones and Android notifications via the Blynk application.

Figure 4 shows that the prototype incorporated various functions to detect gas leaks and notify users. It used gas sensors to identify leaks in the kitchen environment, triggering multiple notification methods, including SMS messages, Android notifications, a sound buzzer, and automatic

closure of the gas tank lid. When a gas leak was detected, the system sent SMS alerts to designated phone numbers, delivered notifications to Android devices via the Blynk application, emitted a loud sound through the buzzer, and automatically closed the gas tank lid to reduce potential hazards. The prototype, however, did not include provisions for cleaning the system or the LPG gas tank. While the design focused on leak detection, user notification, and safety measures, it did not address the maintenance or cleaning requirements of these components.

**Figure 4**

*System boundary*

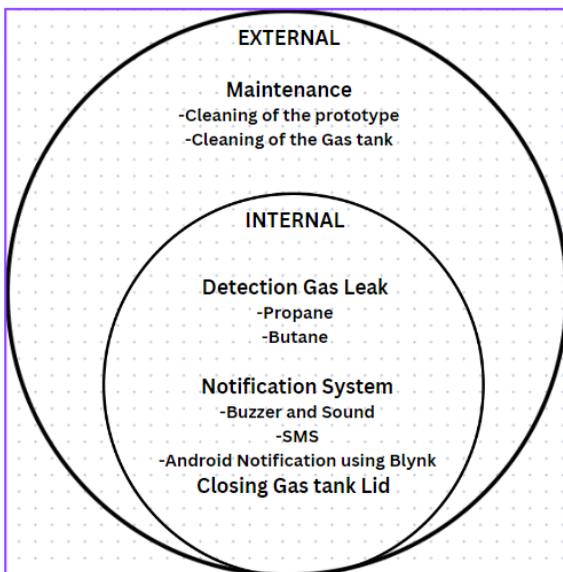
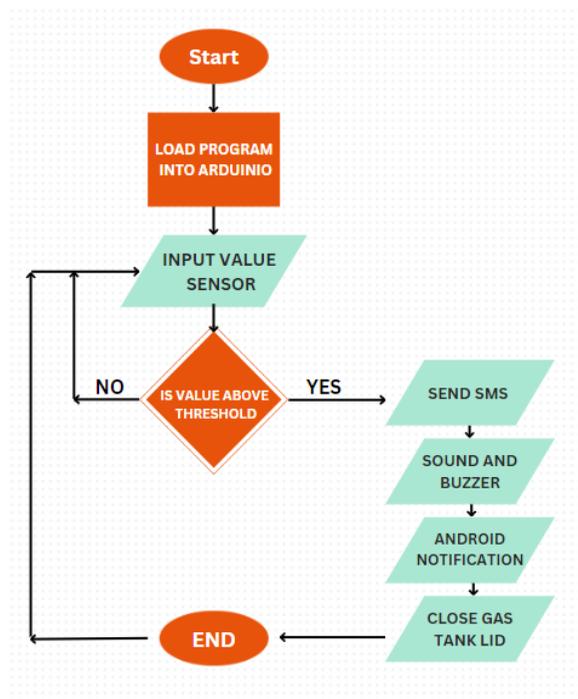


Figure 5 represents the data flow diagram of the proposed system. The system's operation began with initializing all sensors and modules to ensure proper connectivity. The program was loaded onto the Arduino board, which then continuously monitored gas levels in the kitchen. When a gas leak exceeded the predetermined threshold, the system activated several response mechanisms. These included closing the gas tank lid as a

preventive measure, activating a sound alarm and buzzer to alert nearby individuals, sending SMS notifications to designated contacts, and delivering Android notifications to connected devices. After executing these safety measures, the system returned to continuous monitoring of the kitchen environment to maintain safety.

**Figure 5**  
Data flow diagram



**Figure 6**  
Circuit diagram

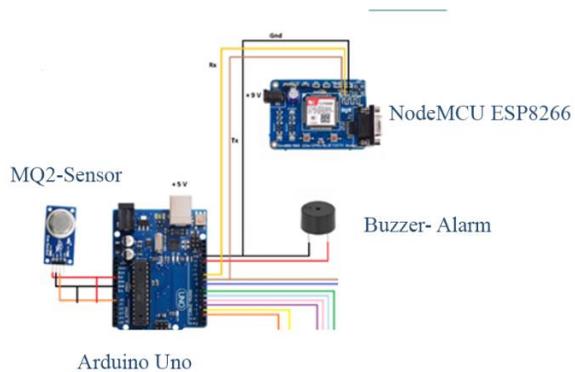


Figure 6 illustrates the overall architecture and circuit layout of the system, designed for ease of installation and use. The system incorporated various components to ensure efficient operation. The Arduino board served as the central control unit, while the NodeMCU ESP8266 module enabled connection to the Blynk application for remote monitoring and control. Gas monitoring was achieved using the MQ2 sensor, recognized for its high sensitivity to gases, ensuring accurate leak detection. A buzzer alarm provided immediate audible alerts when gas levels exceeded a predetermined threshold, allowing prompt response. By effectively integrating these components, the system provided reliable monitoring, remote accessibility, and enhanced safety management.

### ***Testing***

The researchers conducted unit testing, leveraging their familiarity with the system’s code and component design. This approach allowed them to create test cases tailored to the specific functionality and requirements of each component. Unit testing also facilitated the early detection and diagnosis of potential issues, ensuring that individual components functioned correctly before full system integration.

**Figure 7**

*Test case of the propose prototype*



*Test approach.* Unit testing was conducted using specialized software tools that automated the execution of test cases and reporting of

results. These tools enabled the researchers to generate and run multiple test cases while tracking progress and outcomes. Unit testing was essential in accelerating the evaluation process and ensuring comprehensive assessment of each component. Its primary objective was to enhance the system's quality and reliability by identifying and rectifying defects in individual elements before they affected overall functionality.

*Integration testing.* Integration testing was performed to validate the interaction and compatibility between various system components, including the Arduino Uno R3, NodeMCU ESP8266 module, MQ2 gas sensor, Blynk Application, and buzzer alarm. The researchers simulated different scenarios to evaluate system behavior, including the accuracy of gas detection, activation of the alarm, and communication with the Blynk application.

*System testing.* System testing involved simulating various kitchen scenarios and examining the integrated operation of all system components. This phase ensured that the system functioned correctly, responded appropriately to detected gas leaks, and maintained compatibility across all modules.

*Acceptance testing.* Acceptance testing assessed the system's compliance with user requirements and its ability to perform its intended functions. End users or their representatives evaluated the system in real-world kitchen scenarios to confirm its accuracy in detecting gas leaks, timely generation of alerts, and effectiveness in enabling users to take appropriate actions. The usability of the interface, integration with notification systems, and clarity of training materials were also evaluated to ensure a seamless user experience.

### ***Field Trials and Pilot Testing***

Field trials were conducted in real-world environments to obtain actual performance data. This approach allowed the researchers to identify issues that were not evident in controlled laboratory conditions. User feedback gathered during pilot testing was used to refine system design and improve functionality. For example, if the system failed to detect leaks consistently, the researchers adjusted sensor placement or modified detection algorithms to enhance performance.

### ***Deployment and Maintenance***

The deployment strategy involved installing the gas leakage detection system in selected buildings or facilities where active monitoring was required. Sensors were strategically positioned to detect gas leaks promptly and notify users immediately. Regular maintenance and inspections were conducted, including monitoring battery levels, cleaning sensors, and replacing worn or damaged components. Additionally, users received training on system operation and appropriate response protocols in the event of a gas leak.

### ***Observations and Results***

The researchers' observations are presented in this chapter, including results from testing and validation, alongside interpretations based on the study objectives. Safety is paramount in environments using flammable gases, as accidents can occur unexpectedly. The integration of IoT technology facilitated a system capable of detecting gas leaks, alerting users, and preventing further leakage.

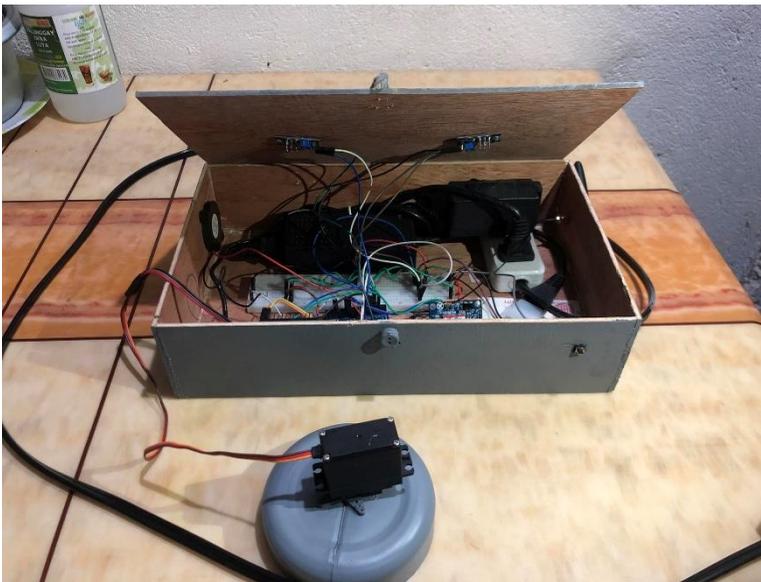
The gas leak detection system developed using Arduino UNO proved effective. Gas sensors accurately detected leaks, triggering alarms

and notifications. Upon detection, the system autonomously shut off the gas supply, ensuring immediate mitigation of potential hazards. Users received instant notifications on their devices, providing timely alerts to take necessary action.

The prototype successfully prevented fires, explosions, and health risks through sensor detection and automatic valve closure. It complied with safety guidelines established by the Bureau of Fire Protection (BFP) and demonstrated reliability in real-world applications. Furthermore, evaluation based on ISO 25010 criteria confirmed the system's high standards of usability, functionality, reliability, and performance efficiency.

### **Figure 8**

*The developed prototype*



The effective utilization of Arduino UNO in designing the gas leakage detection system provided a reliable solution to enhance safety in various environments. By integrating gas sensors, the system accurately detected leaks and enabled prompt responses. Additional safety measures,

including an alarm system and automatic lid closure, further reinforced protection. The developed prototype effectively mitigated the risks of fires, explosions, and health hazards associated with gas leaks, addressing the urgent need for enhanced safety precautions. By employing advanced gas sensors, the system was capable of detecting even minimal leaks, ensuring rapid and effective response measures.

### *System Evaluation / Testing*

This section presented the survey results from 205 respondents calculated using Slovin's formula, and questionnaires were distributed using a random sampling technique. The questionnaire was based on the ISO 25010 standard and covered key aspects of software quality, including functional suitability, reliability, usability, performance efficiency, and maintainability.

**Table 3**

*Weighted mean distribution of the criteria for the developed system*

<b>ISO 25010</b>	<b>Weighted Mean</b>	<b>Remarks</b>
Functional suitability	3.35	Strongly Agree (SA)
Reliability	3.21	Agree (A)
Usability	3.40	Strongly Agree (SA)
Performance efficiency	3.36	Strongly Agree (SA)
Maintainability	3.35	Strongly Agree (SA)
<b>Average</b>	<b>3.33</b>	<b>Strongly Agree (SA)</b>

The functional suitability of the system received a weighted mean of 3.35, indicating a high level of agreement among respondents. Similar results were observed for reliability and maintainability, with weighted means of 3.36 and 3.40, respectively, all corresponding to “strongly agree”

remarks. The system's usability also scored 3.35, indicating strong agreement, while performance efficiency was slightly lower at 3.21, still receiving "agree" remarks. Overall, the average weighted mean across these criteria was 3.33, demonstrating that respondents strongly agreed that the system effectively met the specified requirements, performed efficiently, and was reliable, maintainable, and user-friendly.

The evaluation further indicated that the system successfully fulfilled all specified tasks and user objectives, evidenced by an average weighted mean of 3.44, corresponding to a "strongly agree" remark. This confirmed the system's effectiveness in meeting user expectations and achieving high user satisfaction. User satisfaction is critical for gas leakage detection systems, where an intuitive interface and seamless operation are essential. This finding aligns with Choche et al. (2021), whose study of similar systems showed high satisfaction in usability, reliability, and ease of understanding.

The system's reliability was also affirmed, with a weighted mean of 3.34, reflecting consistent and accurate gas leakage detection. Gas sensors employed advanced algorithms to minimize false alarms and maintain stability, ensuring continuous and dependable operation. This reliability instilled confidence in users regarding the system's ability to detect gas leaks and enhance overall kitchen safety.

The system's usability received an average weighted mean of 3.61, corresponding to a "strongly agree" remark. Users found the interface clear and straightforward, with simple installation procedures, informative feedback, and easily understandable alerts. This allowed homeowners to quickly respond to potential gas leakage incidents, reinforcing trust in the system's effectiveness.

Regarding performance efficiency, the system effectively utilized

the Arduino Uno R3's processing speed, memory, and energy consumption, achieving a weighted mean of 3.34. This ensured that the system operated consistently and efficiently, promptly detecting gas leaks and enabling timely risk mitigation.

Finally, the system's maintainability was highly rated, with a weighted mean of 3.45, indicating that maintenance, troubleshooting, and future enhancements could be performed easily. Clear and well-documented code, a modular design, and standardized components facilitated long-term reliability and effectiveness of the gas leakage detection system.

*Economic feasibility.* The economic feasibility of the system was evaluated to determine whether the expected benefits outweighed or met the anticipated costs. The analysis considered both advantages and disadvantages to assess overall viability. Using the ISO 25010 questionnaire-based assessment, the study gathered insights on the system's efficiency, cost-effectiveness, and potential return on investment.

*Technological feasibility.* The technological feasibility was assessed by evaluating the suitability of Arduino Uno R3 for the sensor-based gas leakage detection system. This evaluation involved examining hardware and software compatibility, gas leak detection accuracy, system reliability, and scalability for future enhancements. Accessibility to development tools and maintenance support was also considered to ensure that the system could be practically implemented and maintained.

*Operational feasibility.* Operational feasibility focused on whether the system could be effectively integrated into real-world kitchen environments. Factors such as user acceptance, technical capability, integration with existing infrastructure, and availability of training and support were analyzed. This assessment confirmed that the Arduino Uno

R3-based system could be practically deployed, meet user requirements, and operate effectively with the necessary tools and expertise.

## **Conclusion**

The study successfully demonstrated the development and implementation of a sensor-based gas leakage detection system, providing a reliable and effective solution to enhance safety in various environments. The integration of gas sensors allowed for accurate detection of even minor leaks, while safety features such as an alarm system, automatic lid closure, and real-time notifications ensured timely alerts to users. The developed prototype effectively mitigated the risks of fires, explosions, and health hazards associated with gas leaks, addressing the urgent need for improved safety measures in homes. Its user-friendly interface enabled intuitive monitoring and response, empowering LPG users to proactively prevent accidents. Furthermore, the system complied with the Bureau of Fire Protection (BFP) safety regulations, incorporating audible and visual alarms to alert nearby individuals, demonstrating its reliability and adherence to established standards. Evaluation based on ISO 25010 criteria confirmed the system's high performance in functionality, reliability, usability, performance efficiency, and maintainability. Overall, the system provided a practical, efficient, and dependable solution for enhancing kitchen safety, ensuring that users could confidently detect and respond to gas leak incidents while minimizing potential hazards.

## Bibliography

- Apeh, S. T., Erameh, K. B., & Iruansi, U. (2014). Design and development of kitchen gas leakage detection and automatic gas shut-off system. *Journal of Emerging Trends in Engineering and Applied Sciences (JETEAS)*, 5(3), 222–228.
- Asafe, Y. N., Oyeranmi, A. J., Olamide, O. A., & Abigael, A. O. (2022). Gas leakage detector and monitoring system. *International Journal of Engineering and Manufacturing (IJEM)*, 12(5), 56–65. <https://doi.org/10.5815/ijem.2022.05.05>
- Bairagi, P. P., Patir, B., Bora, P., Deka, L., & Rajbongshi, S. K. (2024). SmartGuard: An intelligent LPG leakage detection and control system. *International Journal of Engineering Trends and Technology*, 72(9), 265–272. <https://doi.org/10.14445/22315381/IJETT-V72I9P121>
- Brodsky, C. N., Bucala, M. D., Rowland, S. T., & Michanowicz, D. R. (2024). The burden of natural gas leaks on public sector emergency response in the United States. *Energy Policy*, 192, 114214. <https://doi.org/10.1016/j.enpol.2024.114214>
- Choudhary, A. (2024). Internet of Things: A comprehensive overview, architectures, applications, simulation tools, challenges and future directions. *Discovery Internet of Things*, 4, 31. <https://doi.org/10.1007/s43926-024-00084-3>
- Faye, P., Kuhikar, S., Rathod, R., Chandewar, G., & Thakre, K. (2025). Smart IoT based gas leakage detection and auto shut-off system. *International Journal on Advanced Computer Engineering and Communication Technology*, 14(1), 228–234.
- Friday, E. A., Sorlihu, T. O., & Abiodun, A. I. (2025). Smart safety solutions: Real-time SMS alerts for gas leakage and fire detection using IoT. *London Journal of Research in Computer Science & Technology*, 25(2), 52–65.
- Ga, S.-H., Cha, H.-J., & Kim, C.-J. (2021). Adapting Internet of Things to Arduino-based devices for low-cost remote sensing in school science learning environments. *International Journal of Online and Biomedical Engineering (iJOE)*, 17(2), 4–18. <https://doi.org/10.3991/ijoe.v17i02.20089>
- Gao, W., Luo, X., Liu, Y., Zhao, Y., & Cui, Y. (2021). Development of an Arduino-based integrated system for sensing of hydrogen peroxide. *Sensors and Actuators Reports*, 3, 100045. <https://doi.org/10.1016/j.snr.2021.100045>
- Hasibuan, M. S., Syafriwel, & Idris, I. (2019). Intelligent LPG gas leak detection tool with SMS notification. *Journal of Physics: Conference*

Series, 1424, 012020. <https://doi.org/10.1088/1742-6596/1424/1/012020>

- Kuruvilla, S. E., Sumith, A., Datta, G. V., Jeevan, P., & Lithish, M. R. (2025). Real-time detection and alerting system for LPG gas leakage with weight-based consumption tracking. *International Journal for Multidisciplinary Research (IJFMR)*, 7(3). <https://doi.org/10.36948/ijfmr.2025.v07i03.43775>
- Márquez-Sánchez, S., Huerta-Muñoz, J., Herrera-Santos, J., González Arrieta, A., & De la Prieta, F. (2023). Gas sensing in industry: A case study—Train hangar. *Ad Hoc Networks*, 148, 103205. <https://doi.org/10.1016/j.adhoc.2023.103205>
- Mishra, P., Mishra, N., Choudhary, D. K., Pareek, P., & Reis, M. J. C. S. (2025). Use of IoT with deep learning for classification of environment sounds and detection of gases. *Computers*, 14(2), 33. <https://doi.org/10.3390/computers14020033>
- Rathi, B., Thapaswi, S., & Kambhampati, M. (2025). Realizing the potential of Internet of Things (IoT) in industrial applications. *Discovery Internet of Things*, 5, 45. <https://doi.org/10.1007/s43926-025-00141-5>
- Shah, A. S., Dinesh, A., Shah, A., Farooq, M., Maqsood, A., & Khani, M. A. K. (2024). Smart gas leak detection and emergency response system using IoT for homes. *Journal of ICT, Design, Engineering and Technological Science*, 8(1), 18–23. <https://doi.org/10.33150/JITDETS-8.1.3>
- Sharipov, M., Uzokboev, S., Nghia, N. N., Azizov, S., Ryu, W., Tawfik, S. M., & Lee, Y.-I. (2025). Recent progress in Arduino- and smartphone-based sensors for biochemical and environmental analysis. *TrAC Trends in Analytical Chemistry*, 183, 118103. <https://doi.org/10.1016/j.trac.2024.118103>
- Sokienah, Y. (2023).** Exploring the integration of IoT systems in interior design and the built environment: A systematic review. *Heliyon*, 9(12), e22869. <https://doi.org/10.1016/j.heliyon.2023.e22869>
- Subramanian, M. A., Selvam, N., Rajkumar, S., Mahalakshmi, R., & Ramprabhakar, J. (2020). Gas leakage detection system using IoT with integrated notifications using Pushbullet: A review. In *2020 Fourth International Conference on Inventive Systems and Control (ICISC)* (pp. 359–362). IEEE. <https://doi.org/10.1109/ICISC47916.2020.9171093>
- Zreikat, A. I., AlArnaout, Z., Abadleh, A., Elbasi, E., & Mostafa, N. (2025). The integration of the Internet of Things (IoT) applications into 5G networks: A review and analysis. *Computers*, 14(7), 250. <https://doi.org/10.3390/computers14070250>