



# SMART GAS LEAKAGE PREDICTION AND USAGE TRACKING IN LPG CYLINDERS

## *Real-Time Gas Leakage Detection and Consumption Forecasting Using IoT Technology*

<sup>1</sup>Dr. D. Thilagavathy, <sup>2</sup>Hanisika.S, <sup>3</sup>Nandhini.G, <sup>4</sup>Pavyasri.M, <sup>5</sup>Subathra.K

<sup>1</sup>Head of the Department, <sup>2,3,4,5</sup>Student, Information Technology, Adhiyamaan College of Engineering(Autonomous),  
Dr.MGR nagar, Krishnagiri District, Hosur-635109

**Abstract:** Liquefied Petroleum Gas (LPG) is widely used for domestic cooking and small-scale commercial applications due to its efficiency and convenience. Despite its benefits, LPG usage presents significant safety risks when leakage occurs, potentially leading to fire accidents, explosions, and health hazards. In addition to safety concerns, consumers often lack accurate information about the remaining gas level inside the cylinder, resulting in unexpected depletion and inconvenience. To address these challenges, an intelligent monitoring solution integrating Internet of Things (IoT) technology and machine learning techniques is developed. A load cell sensor continuously measures variations in cylinder weight to estimate gas consumption, while an MQ-series gas sensor detects leakage in real time. Sensor data is transmitted through a Wi-Fi-enabled microcontroller to a cloud platform for storage and analysis. Historical consumption patterns are analyzed using a lightweight predictive model to estimate the remaining usage duration. When abnormal gas concentration or sudden weight reduction is identified, instant alerts are delivered through a mobile application to ensure immediate user awareness. In addition, the system maintains a structured database of daily consumption records, enabling trend analysis and improved forecasting accuracy over time. Threshold-based anomaly detection mechanisms further enhance reliability by identifying unusual fluctuations in weight or gas concentration. The cloud interface provides graphical visualization of usage history, assisting users in understanding consumption behavior. By combining real-time sensing, wireless communication, and predictive analytics, the solution offers a scalable and cost-effective approach suitable for smart homes and connected living environments.

**Index Terms:** Internet of Things (IoT), LPG Leakage Detection, Gas Consumption Monitoring, Machine Learning Prediction, Cloud-Based Alert System.

### I. INTRODUCTION

Liquefied Petroleum Gas (LPG) is extensively utilized for cooking and heating purposes in homes and small commercial establishments because of its high energy output and clean-burning nature. Although LPG offers several advantages, it also poses serious safety risks due to its inflammable characteristics. Leakage of gas can lead to dangerous situations such as fires, explosions, and respiratory health issues. Such leakages commonly occur due to worn-out regulators, defective pipelines, improper installation, or insufficient maintenance. In most residential settings, gas leakage is identified only through the odor added to LPG, which may fail to provide immediate or dependable alerts, particularly in enclosed or unattended areas. Along with safety risks, users frequently experience difficulty in knowing the exact amount of gas remaining in the cylinder. Conventional LPG cylinders lack any built-in indication system, forcing users to depend on unreliable manual methods to estimate gas availability. This often results in unexpected exhaustion of gas during daily activities. Advances in sensing devices and wireless communication technologies make it possible to continuously track cylinder weight and surrounding gas levels. By analyzing stored consumption data using predictive techniques, future gas usage trends and expected depletion time can be estimated accurately. This predictive capability enables timely refilling and reduces inconvenience. The combination of continuous leakage detection and usage forecasting greatly improves safety, efficiency, and effective energy management in modern households.

## II. LITERATURE REVIEW

**Table 1: Literature Review of LPG Leakage Detection and Usage Prediction Systems**

S.No.	Study	Objective	Results	Techniques Used	Datasets
1	Smart Gas Leakage Detection Using IoT – Niveditha N. et al. (2025)	Detect LPG leakage using IoT.	Real-time-leakage alerts achieved.	MQSensor, ESP8266, IoT Cloud	Prototype hardware setup
2	SmartGuard: An Intelligent LPG Leakage Detection and Control System – P. P. Bairagi et al. (2024)	Develop intelligent LPG safety system.	Automatic gas shut-off implemented	Gas Sensor, Control Valve, MCU	Controlled experimental testing
3	Smart LPG Gas Level Monitoring and Leakage Detection System – V. M. Umale et al. (2023)	Monitor gas level and leakage.	Continuous level monitoring enabled.	Load Cell, MQ Sensor, IoT Module	Real-time cylinder data
4	IoT-Based Gas Monitoring and Alert System – R. Sharma et al. (2022)	Wireless gas monitoring system.	SMS-based leak alert system.	GSM Module, Gas Sensor	Domestic test environment
5	Machine Learning-Based Energy Consumption Prediction – S. Kumar et al. (2021)	Predict energy consumption.	Consumption prediction accuracy improved.	Linear Regression Model	Historical usage dataset

### • Smart Gas Leakage Detection Using IoT

This study presents an Internet of Things based framework for detecting LPG leakage in domestic environments to enhance household safety. The authors emphasize that conventional detection methods relying on human smell perception are unreliable and often delayed, especially during nighttime or unattended conditions. To overcome this limitation, the system integrates an MQ series gas sensor with a Wi Fi enabled microcontroller to continuously monitor gas concentration levels. When the sensed value exceeds a predefined safety threshold, the controller triggers an alert mechanism and transmits notifications to a cloud platform for remote access. The proposed architecture consists of sensing, processing, and communication modules designed to operate with minimal power consumption and low implementation cost. Experimental validation was carried out under controlled laboratory conditions by simulating leakage scenarios. The results demonstrated rapid detection capability and timely alert transmission, reducing response time compared to manual identification methods. The study confirms that IoT connectivity improves monitoring flexibility by enabling real time status tracking through smartphones or web dashboards. However, the system focuses solely on leakage identification and does not incorporate cylinder weight monitoring or consumption analysis features. The absence of predictive capabilities limits its application to safety alerts only. Despite this constraint, the research contributes significantly to the development of affordable smart safety systems. It establishes that integrating gas sensors with wireless communication technologies can effectively minimize domestic hazards and improve preventive safety standards in residential settings through continuous environmental monitoring and automated notification mechanisms.

- **SmartGuard: An Intelligent LPG Leakage Detection and Control System**

This research introduces an intelligent LPG monitoring solution that combines leakage detection with automated control to prevent hazardous incidents. The authors recognize that early detection alone may not be sufficient if immediate preventive action is not taken. Therefore, the system integrates a gas sensor, microcontroller, and an electronically controlled shut off valve capable of restricting gas flow during abnormal conditions. Continuous monitoring of gas concentration is performed, and the sensed values are compared against predefined safety thresholds. When the gas level surpasses the permissible range, the controller activates a relay mechanism that closes the valve and simultaneously generates alert notifications for the user. The implementation emphasizes real time response and reliability, ensuring that corrective action occurs without manual intervention. Laboratory experiments were conducted by simulating controlled leakage scenarios to evaluate system responsiveness and functional accuracy. Results indicate that the automated valve mechanism successfully minimized gas release and significantly reduced potential fire risks. The integration of sensing and actuation provides a more comprehensive safety approach compared to simple alert systems. However, the design introduces additional hardware complexity and increases overall cost due to the inclusion of mechanical control components. Furthermore, the framework does not support cylinder weight monitoring or usage forecasting capabilities. Despite these limitations, the research demonstrates the importance of combining detection and preventive control in smart LPG safety solutions. The study contributes to safer domestic and commercial environments by presenting a system that not only identifies hazards but also actively mitigates them through automated intervention and intelligent control mechanisms.

- **Smart LPG Gas Level Monitoring and Leakage Detection System Using IoT**

This study proposes an IoT enabled system designed to monitor LPG cylinder weight and detect leakage simultaneously, addressing both safety and usability challenges. The authors highlight that sudden gas depletion during cooking creates inconvenience, while leakage incidents pose serious hazards. To solve these issues, the framework integrates a load cell sensor placed beneath the cylinder to measure weight variations continuously. The measured values are processed through a microcontroller and transmitted to a cloud platform via wireless communication. In addition to weight monitoring, a gas sensor module detects abnormal gas concentration in the surrounding environment. The collected data is accessible through a mobile interface, allowing users to observe real time cylinder status remotely. Experimental evaluation was conducted by recording daily weight changes and simulating leakage conditions to test responsiveness. The results showed consistent weight measurement accuracy and effective alert generation during hazardous situations. The system successfully improves user awareness regarding both gas availability and environmental safety. However, the research mainly focuses on real time monitoring and does not incorporate advanced predictive algorithms for estimating future consumption patterns. The absence of forecasting capability restricts long term planning features. Despite this limitation, the study demonstrates the practical feasibility of integrating multiple sensors with IoT connectivity to enhance domestic LPG management. It establishes a foundation for further development of intelligent monitoring solutions that combine safety detection with analytical capabilities for improved household efficiency and operational convenience.

- **IoT Based Gas Monitoring and Alert System**

This research presents a wireless gas monitoring system developed to enhance residential safety through remote alert mechanisms. The authors note that many households lack automated warning systems capable of detecting gas accumulation at early stages. The proposed framework integrates a gas sensor with a microcontroller and a GSM communication module to provide notification services. When gas concentration exceeds the safe operating threshold, the system sends instant text messages to predefined contacts. The architecture emphasizes simplicity, affordability, and ease of installation, making it suitable for widespread domestic deployment. Experimental testing was performed in a simulated household environment to validate detection sensitivity and message transmission reliability. Results indicate stable sensor performance and timely alert delivery during leakage scenarios. The design ensures low power consumption and minimal hardware requirements. However, the framework does not include cloud data storage or long term analytics for consumption tracking. It also lacks weight measurement and predictive estimation features. The system primarily addresses leakage detection without offering comprehensive gas management capabilities. Despite these constraints, the study highlights the effectiveness of integrating sensor based detection with wireless communication to reduce domestic risks. The research supports the importance of early warning mechanisms in preventing fire related accidents and improving user response time. It demonstrates that even simple IoT implementations can significantly strengthen safety measures in residential settings when properly configured and maintained.

- **Machine Learning Based Energy Consumption Prediction**

This study investigates the application of machine learning algorithms for forecasting energy consumption using historical usage data. The authors emphasize that predictive analytics can improve planning efficiency and resource management in various energy systems. A regression based supervised learning model was developed to analyze time series consumption records and estimate future usage patterns. The dataset included structured historical energy readings collected over a defined observation period. Data preprocessing techniques were applied to remove noise and normalize input values before training the model. The algorithm was evaluated using training and validation splits to measure predictive accuracy and generalization performance. Results demonstrated improved forecasting capability compared to traditional statistical estimation approaches. The study highlights that machine

learning models can effectively capture consumption trends and seasonal variations when sufficient historical data is available. Although the research is not specifically targeted toward LPG cylinders, the methodology is highly adaptable to gas usage prediction scenarios. The absence of domain specific implementation for LPG systems is identified as a limitation. Nevertheless, the findings strongly support the integration of predictive algorithms into smart monitoring frameworks. By leveraging historical consumption data, forecasting models can assist users in planning timely refills and optimizing resource usage. The research provides a conceptual foundation for incorporating machine learning techniques into intelligent LPG management systems, thereby extending safety solutions with analytical insights that enhance operational efficiency and long term sustainability.

### III. PROPOSED SYSTEM: IoT-ENABLED LPG LEAKAGE MONITORING AND CONSUMPTION FORECASTING

The proposed system introduces an intelligent IoT-enabled framework for real-time LPG leakage detection and consumption forecasting to enhance domestic safety and operational efficiency. The LPG cylinder acts as the primary gas source whose weight and environmental gas concentration are continuously monitored. A load cell sensor integrated with the HX711 amplifier module is installed beneath the cylinder to capture precise weight variations. These measurements are processed to calculate real-time LPG consumption and estimate the remaining gas level accurately. This continuous monitoring eliminates uncertainty regarding cylinder status and prevents sudden gas depletion during usage. To ensure safety, an MQ-2 gas sensor is deployed to detect LPG concentration in the surrounding environment. The sensor continuously measures gas levels and identifies abnormal increases that indicate potential leakage. All sensor data is collected and processed by the ESP32 microcontroller, which functions as the central control unit of the system. The controller performs initial filtering and threshold comparison before transmitting the processed information to a cloud-based IoT platform using Wi-Fi or GSM communication. The cloud server stores historical consumption data and supports analytical processing. A machine learning-based predictive model analyzes usage trends over time to estimate the remaining duration of LPG availability and forecast refill requirements in advance. This prediction mechanism enables proactive planning and improves household energy management. In case of detected leakage, abnormal usage behavior, or critically low gas levels, an integrated alert system immediately generates notifications or SMS messages to inform users. A dedicated mobile application interface provides real-time monitoring, graphical visualization of consumption analytics, leak status indication, and intelligent refill forecasting. The integration of sensing modules, wireless communication, cloud analytics, and predictive modeling creates a comprehensive smart LPG monitoring solution that improves safety, enhances reliability, and supports data-driven decision-making in modern residential environments.

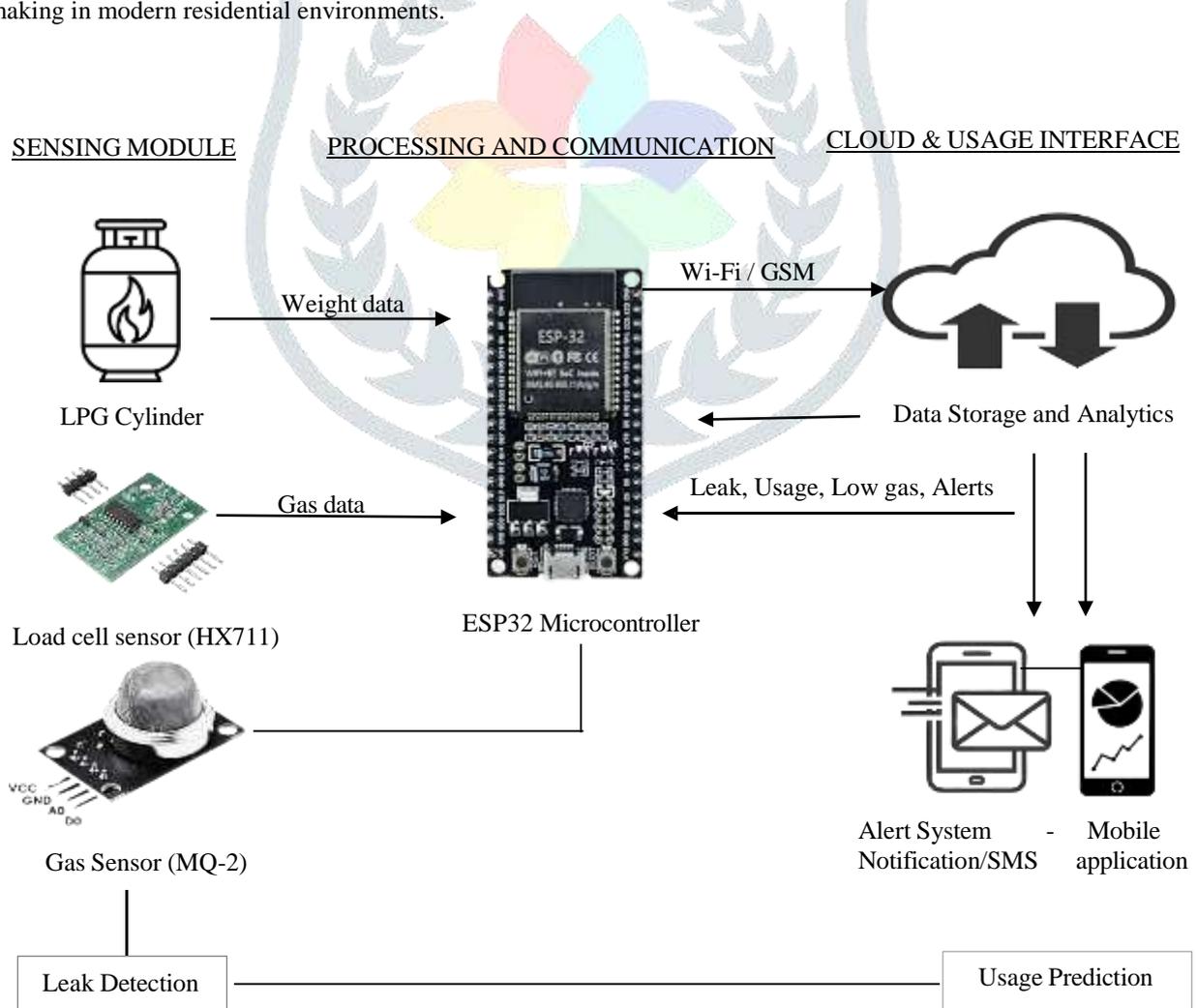


Figure 1: Architecture Diagram

#### IV. PROJECT FUNCTIONAL MODULES IMPLEMENTATION

The Smart LPG Leak Detection and Usage Prediction system is implemented through multiple functional modules that operate collaboratively to ensure safety, monitoring accuracy, and predictive analysis. Each module is designed to perform a specific task within the overall architecture. The sensing module forms the foundation of the system. It consists of a load cell integrated with the HX711 amplifier to measure real-time variations in LPG cylinder weight. These measurements are continuously recorded to calculate gas consumption and determine the remaining LPG level. In parallel, the MQ-2 gas sensor monitors the surrounding environment to detect the presence of leaked gas. The sensor readings are compared with predefined safety thresholds to identify abnormal gas concentration levels. The processing module is centered on the ESP32 microcontroller, which acts as the system controller. It collects input data from both the load cell and gas sensor, performs signal conditioning, and converts analog readings into digital values for analysis. The controller executes programmed logic to detect leakage conditions, sudden weight drops, or low gas levels. When such conditions are identified, appropriate control actions are initiated. The communication module enables real-time data transmission to the cloud platform using Wi-Fi or GSM connectivity. Sensor readings and system status updates are uploaded periodically to ensure continuous remote monitoring. The cloud module stores historical data and performs analytical processing. A machine learning algorithm analyzes previous consumption trends to estimate remaining usage duration and predict refill requirements. The alert and user interface module ensures effective interaction with the end user. In case of leakage detection or abnormal consumption behavior, instant notifications or SMS alerts are generated. A mobile application provides real-time visualization of cylinder status, usage graphs, leak alerts, and predictive refill information. Through these integrated functional modules, the system delivers enhanced safety, operational efficiency, and intelligent LPG management for modern households.

#### V. MATHEMATICAL MODELING FOR LPG MONITORING AND PREDICTION

The proposed Smart LPG monitoring system applies mathematical modeling to estimate gas availability, consumption rate, leakage conditions, and future refill requirements. The remaining LPG quantity inside the cylinder is calculated using weight-based measurement. The total cylinder weight is continuously measured using a load cell sensor. The actual gas weight is obtained by subtracting the empty cylinder weight from the total measured weight:

$$W_{\text{gas}} = W_{\text{total}} - W_{\text{empty}}$$

To determine usage behavior, the gas consumption rate is calculated over a specific time interval. The difference between two consecutive weight readings divided by the time interval provides the rate of usage:

$$R = \frac{W_{\text{prev}} - W_{\text{current}}}{\Delta t}$$

Where R represents the consumption rate. The estimated remaining duration of LPG availability is then calculated using the average consumption rate:

$$D = \frac{W_{\text{remaining}}}{R_{\text{avg}}}$$

Where D denotes the predicted remaining days.

For improved forecasting accuracy, a Linear Regression model is applied to historical consumption data stored in the cloud platform. The prediction model follows:

$$\hat{y} = mx + c$$

Where x represents time,  $\hat{y}$  represents predicted consumption, m indicates the rate of change in usage trend, and c is the intercept constant. This model enables estimation of future gas levels and expected refill timing.

Leakage detection is implemented using a threshold-based condition. If the measured gas concentration exceeds the predefined safety limit:

$$G_{\text{value}} > G_{\text{threshold}}$$

The system triggers an alert notification.

By integrating weight analysis, rate calculation, regression forecasting, and threshold comparison, the mathematical model ensures accurate monitoring, predictive analysis, and enhanced household safety.

### VI. SMART LPG PROTOTYPE, ALGORITHM AND PROGRAM LOGIC

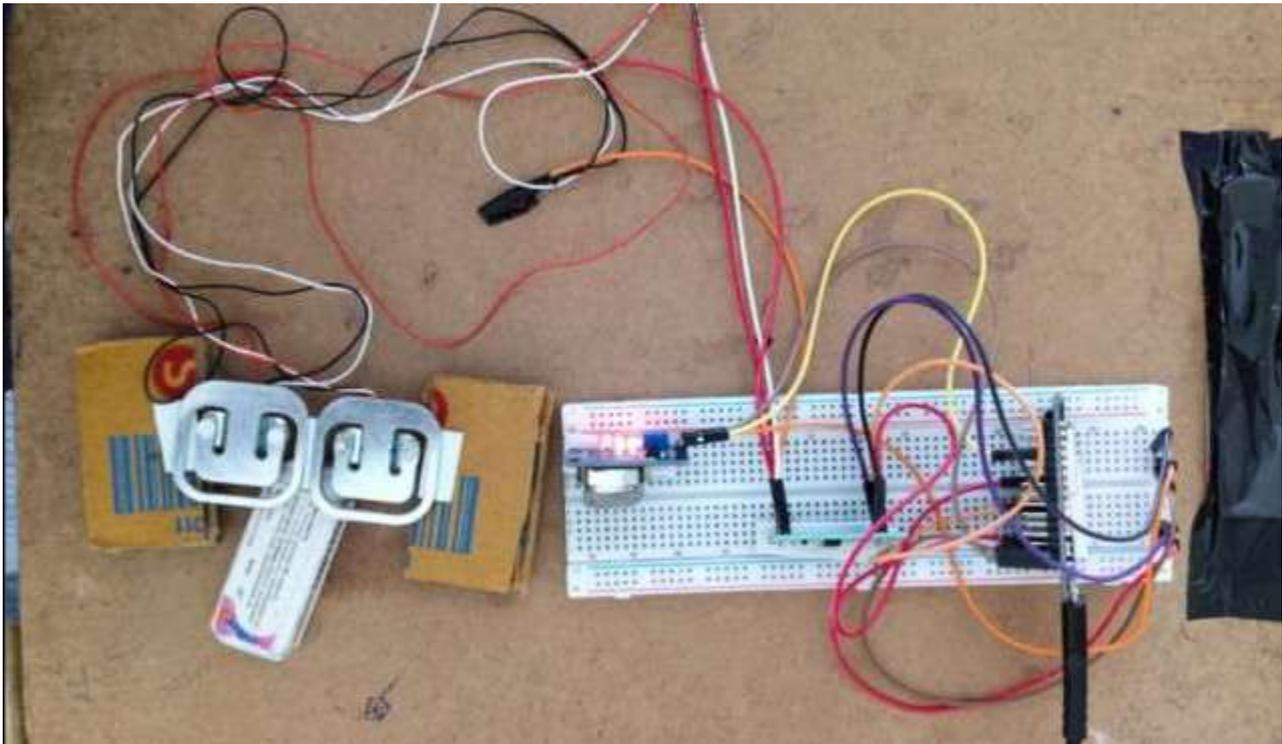


Figure 1: IOT Connection prototype

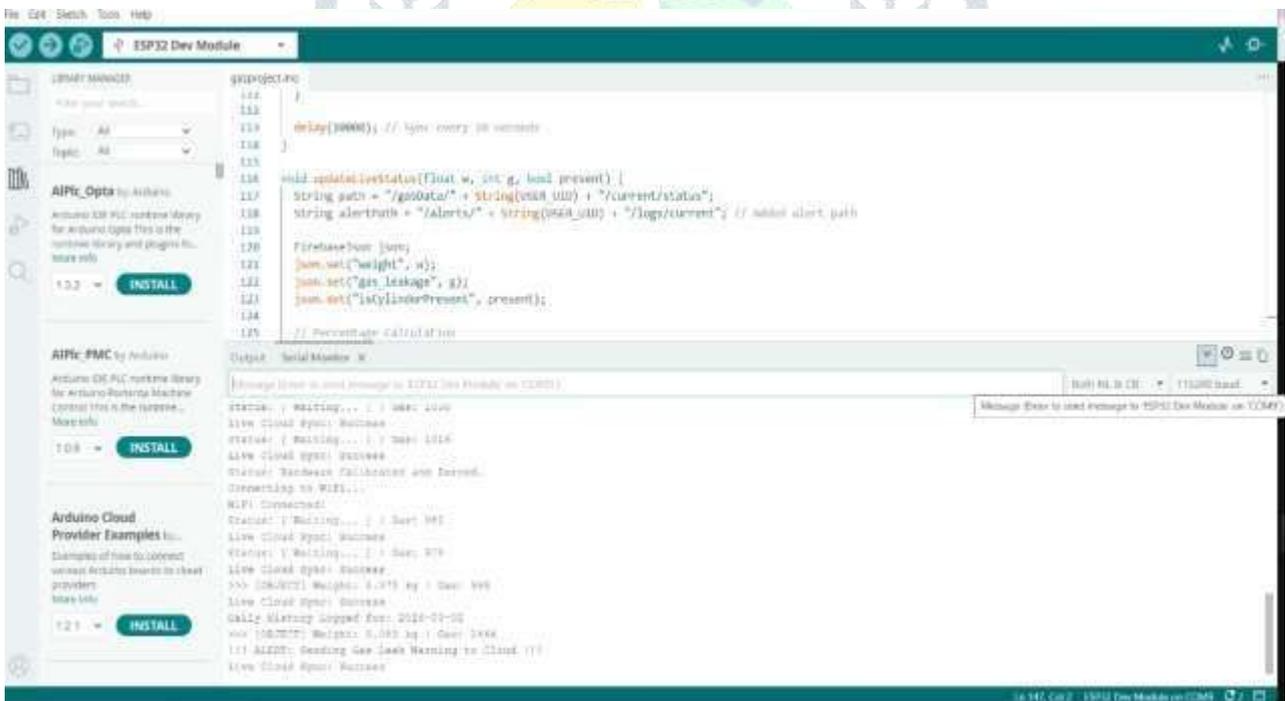


Figure 2: Real-Time ESP32-Based LPG Monitoring, Leak Detection and Cloud Alert Implementation

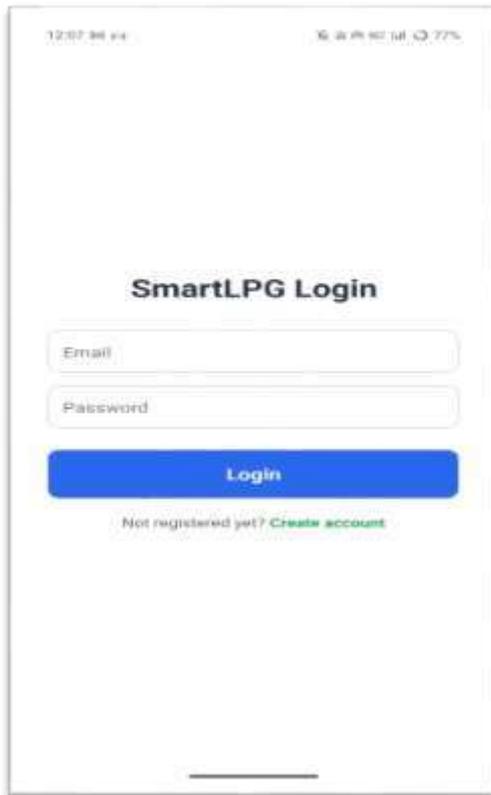


Figure 3: Login page Figure 4: Dashboard page



Figure 5: Usage page



Figure 6: Alert Page



Figure 7: History Page

## VII. METHODOLOGY FOR DEVELOPING THE SMART LPG LEAK DETECTION AND USAGE PREDICTION SYSTEM

The development of the Smart LPG Leak Detection and Usage Prediction system follows a systematic approach integrating hardware configuration, data acquisition, cloud processing, and predictive analytics. The primary objective is to ensure accurate monitoring of LPG levels while enhancing safety through real-time leakage detection. The initial stage involves sensor integration. A load cell combined with the HX711 amplifier is installed beneath the LPG cylinder to continuously measure weight variations. The remaining gas quantity is calculated by subtracting the empty cylinder weight from the measured total weight. An MQ-2 gas sensor is positioned near the cylinder to monitor ambient gas concentration and detect potential leakage. Both sensors are interfaced with the ESP32 microcontroller, which functions as the central control unit. In the next stage, sensor data is collected at regular intervals and converted into digital values for processing. Threshold comparison is applied to identify abnormal gas concentration levels. The ESP32 transmits processed data to a cloud-based IoT platform using Wi-Fi or GSM communication for remote monitoring and storage. The stored historical data is analyzed using a Linear Regression model to estimate future consumption trends and predict refill timing. If leakage is detected or gas levels fall below a predefined limit, instant alerts are generated through SMS or mobile notifications. This structured methodology ensures reliable monitoring, improved household safety, and efficient LPG management.

## VIII. SMART LPG SYSTEM FINDINGS AND RESULTS DISCUSSION

The experimental evaluation of the Smart LPG Leak Detection and Usage Prediction system demonstrates reliable performance in monitoring cylinder weight, detecting leakage, and forecasting gas consumption. The load cell sensor accurately measured real-time weight variations, enabling precise calculation of remaining LPG levels. Repeated testing under controlled conditions showed consistent readings with minimal deviation, confirming measurement stability. The MQ-2 gas sensor effectively detected simulated leakage scenarios by identifying increased gas concentration levels beyond the predefined safety threshold. Alert notifications were successfully triggered within a short response time, ensuring immediate user awareness. Data collected over multiple usage cycles was stored in the cloud platform for analysis. The consumption rate was calculated based on daily weight differences, providing meaningful insights into household gas usage patterns. The Linear Regression model applied to historical data produced dependable predictions of future consumption trends. The predicted refill dates closely matched actual depletion time, indicating acceptable forecasting accuracy for domestic applications. The integration of real-time monitoring and predictive analytics significantly improved system functionality compared to traditional manual observation methods. Users were able to track gas levels remotely through the mobile interface and receive timely alerts for low gas conditions or leakage detection. Overall, the system demonstrated enhanced safety, improved operational efficiency, and effective resource planning capability. These findings validate the practicality of combining IoT sensing, cloud analytics, and machine learning techniques for intelligent LPG cylinder management in residential environments.

## IX. CONCLUSION

The Smart LPG Leak Detection and Usage Prediction system presents an integrated solution that enhances household safety and improves gas consumption management through the use of IoT and predictive analytics. The system successfully combines real-time leakage detection, continuous weight monitoring, cloud-based data storage, and machine learning-based forecasting into a unified framework. By utilizing a load cell sensor for accurate weight measurement and an MQ-2 gas sensor for environmental monitoring, the system ensures both safety and operational awareness. The ESP32 microcontroller efficiently processes sensor data and enables seamless communication with the cloud platform for remote access. The implementation demonstrates that real-time monitoring significantly reduces the risk associated with LPG leakage by providing instant alerts to users. Additionally, the analysis of historical consumption data through a Linear Regression model allows accurate estimation of remaining gas duration and refill prediction. This predictive capability minimizes unexpected gas depletion and supports proactive planning. The mobile application interface further enhances user convenience by offering real-time updates, graphical usage insights, and timely notifications. Overall, the proposed system provides a cost-effective, reliable, and scalable solution for modern residential environments. The integration of sensing technology, wireless communication, and predictive modeling validates the potential of smart monitoring systems in improving safety standards and energy management practices. The results confirm that intelligent LPG monitoring can contribute to safer households and more efficient resource utilization.

## REFERENCE

- [1] N. Niveditha, B. Harshini, and M. Peria Mahalakshmi, "Smart Gas Leakage Detection Using IoT," *International Journal of Innovative Research in Engineering and Technology*, vol. 12, no. 2, pp. 45–52, 2025.
- [2] P. P. Bairagi, S. Das, R. Mukherjee, and A. Chatterjee, "SmartGuard: An Intelligent LPG Leakage Detection and Control System," *International Journal of Advanced Computer Science and Applications*, vol. 15, no. 1, pp. 210–218, 2024.
- [3] V. M. Umale, S. R. Patil, and A. S. Deshmukh, "Smart LPG Gas Level Monitoring and Leakage Detection System Using IoT," *International Journal of Engineering Research and Technology*, vol. 12, no. 5, pp. 678–684, 2023.
- [4] R. Sharma, P. Verma, and K. Singh, "IoT-Based Gas Monitoring and Alert System for Domestic Safety," *IEEE Access*, vol. 10, pp. 98765–98774, 2022.
- [5] S. Kumar, R. Gupta, and M. Tiwari, "Machine Learning-Based Energy Consumption Prediction Using Linear Regression," *International Journal of Energy Research*, vol. 45, no. 8, pp. 11234–11245, 2021.
- [6] A. M. Roy and J. Bhaduri, "A Deep Learning Enabled Multi-Class Plant Disease Detection Model Based on Computer Vision," *AI*, vol. 2, no. 3, pp. 413–428, 2021.
- [7] L. Liu and X. Wang, "Plant Diseases and Pests Detection Based on Deep Learning: A Review," *Plant Methods*, vol. 17, no. 1, pp. 1–18, 2021.
- [8] S. Rajalakshmi and D. Mahalakshmi, "Wireless Gas Leakage Monitoring System Using GSM Technology," *International Journal of Scientific Research in Computer Science*, vol. 7, no. 4, pp. 55–60, 2019.
- [9] M. A. A. Alshahrani and M. M. Khan, "Design and Implementation of Smart Gas Detection System Using Arduino," *International Journal of Computer Applications*, vol. 179, no. 7, pp. 22–27, 2018.
- [10] A. Kamal and M. A. Islam, "Low-Cost Gas Leakage Detection and Alert System," in *Proc. International Conference on Electrical Engineering and Information Communication Technology (ICEEICT)*, 2016, pp. 1–5.