

IOT BASED SMART LPG MONITORING AND SAFETY SYSTEM

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Abstract- Keeping track of LPG cylinder levels and ensuring safety can be a real hassle. This project tackles these issues head-on by introducing an intelligent monitoring system for LPG cylinders. The system uses a load sensor to constantly track the weight of the cylinder, providing real-time data on the remaining gas. When the gas level dips below a set point, the system springs into action, automatically placing a refill order through a connected platform. Furthermore, the system incorporates advanced gas sensors to vigilantly watch for any leaks, ensuring immediate alerts and preventative measures are taken to safeguard the surroundings.

Currently, managing LPG often relies on manual checks and estimations, which can lead to unexpected depletion and potential service interruptions. Existing leak detection methods, if present, may not be automated or may lack the ability to take immediate preventative action. These limitations can result in inconvenience for users and, more importantly, pose significant safety risks in the event of a gas leak.

To overcome these drawbacks, this project proposes a comprehensive system that automates both gas level monitoring and safety protocols. By continuously tracking the cylinder's weight, the system ensures timely refills, eliminating the risk of running out of gas. Moreover, the automated gas leak detection, coupled with the immediate shut-off of the regulator and power sources, along with ventilation activation, significantly enhances safety and minimizes potential hazards. This proactive approach offers users a convenient, reliable, and, most importantly, safe way to manage their LPG supply.

Keywords- LPG monitoring system, Gas leak detection, Load sensor, Real-time tracking, Automated refill system, Safety automation, IoT-based solution, Smart home safety, Weight-based monitoring, Regulator shut-off, Power source control, Ventilation activation.

I INTRODUCTION

The Internet of Things (IoT) is a transformative technology that connects physical objects to the digital world, enabling them to interact, communicate, and share data. These objects are equipped with sensors, actuators, software, and internet connectivity, making them "smart" and capable of responding intelligently to various conditions. IoT goes beyond traditional machine-to-machine communication by integrating devices with advanced analytics and cloud computing, enabling a seamless flow of information.

IoT's origins can be traced back to the late 20th century, but its exponential growth in recent years has been driven by advancements in wireless communication, affordable hardware, and data-processing technologies. The network is not limited to consumer devices but spans a wide spectrum, including industrial equipment, healthcare systems, urban infrastructure, and environmental monitoring.

At its core, IoT aims to create a highly interconnected ecosystem where devices collaborate to simplify human life, enhance efficiency, and tackle global challenges. By unlocking new possibilities, such as predictive insights and real-time control, IoT has become a cornerstone of modern technological advancements, paving the way for smart cities, homes, and industries.

II RELATED WORKS

Ranjith Kumar et al.'s 2023 [1] paper in the ICSSAS presents a system designed for real-time LPG gas level monitoring and leakage detection, highlighting the inherent dangers of LPG due to its flammability and the challenges in accurately assessing cylinder capacity and leaks. Their research focuses on creating a system that provides immediate information on the gas level and promptly identifies leaks, utilizing gas detectors and load cells for these purposes. Upon detecting a leak, the system triggers a buzzer to alert users, while a television display shows the gas quantity alongside alert messages. The authors emphasize that their design not only informs users about the gas level, particularly during refills, but also acts as a crucial tool for preventing gas leakage incidents and enhancing overall safety, thereby contributing to the advancement of LPG cylinder technology.

Ahsan et al.'s 2023 [2] paper introduces an IoT-based interactive LPG cylinder monitoring system tailored for developing countries, aiming to modernize conventional LPG usage with enhanced safety and convenience. Their approach features a robust model with a custom PCB designed for easy integration with existing cylinders, a user-friendly mobile application connected via a central server, and the incorporation of various sensors to provide gas leakage alarms and minimize gas wastage. Notably, the system includes an automated prediction feature to forecast future LPG consumption based on user patterns, contributing to a more intelligent and efficient system. The authors validate their design through both simulation-based indoor experiments and practical outdoor trials, demonstrating the accuracy and reliability of the complete system.

Unnikrishnan et al.'s 2017 [17] paper presented at WiSPNET proposed an LPG monitoring and leakage detection system aimed at addressing the widespread use of LPG by enabling regular usage monitoring and hazard alerts. Their work focused on designing a system capable of informing users about the remaining LPG quantity to facilitate timely action and, crucially, alerting users with an alarm in the event of a gas leak, thereby enabling preventative measures against potential explosions due to the highly flammable nature of LPG. The core objectives of their proposed system were to enhance user awareness of LPG levels and to provide a safety mechanism through leak detection and immediate alerts.

Gomes et al.'s 2018 [10] paper presented at LATINCOM addressed the critical issue of domestic accidents caused by gas leaks, particularly carbon monoxide (CO) and liquefied petroleum gas (LPG), by proposing an IoT-based smart solution. Their work focused on the design and construction of a plug-and-play multi-gas sensor capable of detecting both CO and LPG, intended for integration into smart environments to prevent accidents. The developed device utilizes the IEEE 802.15.4 standard for communication with a border router, which then makes the sensor data accessible to other devices through a middleware. This approach enables other smart devices within the same context to receive gas readings and trigger appropriate actions, and the created prototype was successfully evaluated and validated, demonstrating its readiness for practical deployment.

Dewi and Somantri's 2017 [6] ISMEE paper, published in 2018, addressed the prevalent issue of LPG explosions resulting from undetected leaks by proposing a Wireless Sensor Network (WSN) for gas leak detection coupled with an automatic gas regulator system controlled by Arduino. Recognizing that leaks can occur at various points, their system employs multiple MQ-6 gas sensors connected via Bluetooth HC-05 to an Arduino platform to monitor different locations around the gas cylinder and distribution line. Upon detecting a gas leak, the WSN triggers an explosion prevention system that activates an alarm/buzzer, automatically shuts off the gas regulator, and turns on an exhaust fan to disperse the leaked gas, all orchestrated by the Arduino microcontroller to enhance safety.

Sovlukov and Tereshin's 2004 [5] paper in IEEE Transactions on Instrumentation and Measurement explored the quantitative measurement of liquefied petroleum gas parameters using radio-frequency (RF) techniques. Their proposed RF measurement method aimed to provide highly accurate determination of the LPG level (gas-liquid interface), density, and mass of both the liquid and gaseous phases, as well as the total mass within a tank. The system they designed incorporated three RF sensors: two-level sensors and a gas density sensor. The informative parameters, specifically the resonant frequencies of electromagnetic oscillations from these sensors, were processed together to yield the necessary data. The paper detailed the experimental procedures conducted and presented the measurement results obtained, culminating in the description of an industrial RF measuring system for LPG quantity assessment.

Suma V et al.'s 2019 [19] ICECA paper presented an IoT-based gas leakage detection and monitoring system aimed at addressing the serious problem of gas leaks in domestic and other LPG-using environments. Their proposed system not only incorporates a gas leakage sensor that sends SMS alerts to users upon detection but also automates the gas refill booking process. By utilizing a load cell to continuously monitor the LPG cylinder's weight, the system triggers an automatic refill order to the gas agency via Wi-Fi when the gas level falls below a predefined threshold, subsequently sending a booking status notification back to the customer. Additionally, the authors developed application software for the gas enterprise to manage and record these automatic bookings, highlighting the system's ability to enhance safety through leak detection and streamline the gas refill process for both consumers and suppliers using IoT technology.

Medeiros et al.'s 2017 [7] IEEE paper presented "Smartgas," an IoT platform aimed at modernizing the monitoring of domestic cooking gas usage. Recognizing the growing prevalence of internet-connected devices, their research addressed everyday challenges faced by users of bottled LPG by developing a two-pronged system. This system comprised a user-friendly mobile application designed to display the remaining LPG quantity in a cylinder and an intelligent support infrastructure providing real-time data to the application. This backend component was responsible for continuously monitoring the cylinder's weight to

estimate the gas level and for detecting the occurrence of any gas leaks. The authors emphasized that their "Smartgas" solution contributes to the advancement of smart cities by offering domestic LPG users increased ease of use, enhanced convenience in managing their gas supply, and the potential for economic benefits through better consumption awareness, alongside improved safety measures provided by the leak detection capability.

Deshmukh et al.'s 2016 [12] ISESD paper presented a conceptual architecture for a portable and cost-effective system designed for remote monitoring and control of wireless sensor nodes for LPG gas leakage detection, utilizing LabVIEW for virtual instrumentation and internet connectivity to cover a broad monitoring area. Their work addressed the growing need for flexible gas monitoring systems in various applications, emphasizing the importance of detecting LPG/CNG leaks for safety. The proposed system employs wireless sensor nodes, the data from which is monitored using G-code created in LabVIEW, offering intelligent communication and replacing wired connections in the gas sensing system. The authors highlighted the potential of their prototype model to be valuable for both industrial applications and the general public in instantly detecting LPG/CNG gas leaks.

Macker et al.'s 2018 [4] ICOEI paper tackled the prevalent issues surrounding LPG usage in a country like India, where widespread piped gas supply isn't feasible. They highlighted the shortcomings of existing LPG booking systems, particularly the inconvenience and accessibility barriers for uneducated individuals and busy professionals using IVRS or online methods. Furthermore, they pointed out the difficulty in predicting when an LPG cylinder will run out, leading to delays in booking and potential disruptions. To address these challenges, the authors proposed an innovative Arduino-based system designed to automate the entire LPG cylinder booking process. This system continuously monitors the weight of the cylinder using a sensor, and upon detecting that the gas level is low, it automatically sends a message to the authorized LPG agent, triggering a timely delivery without any manual intervention from the user. Recognizing the safety concerns associated with LPG, their system also integrates a crucial feature for real-time monitoring of gas leakage. If a leak is detected, the system promptly alerts the user, enabling them to take immediate action to prevent potentially life-threatening accidents. The authors aimed to create a more user-friendly, efficient, and safer approach to LPG management by combining automated booking with continuous monitoring and alerts.

III PROPOSED SYSTEM MODEL

This project introduces an intelligent and automated system designed to enhance the safety and convenience of LPG cylinder usage. By continuously monitoring the cylinder's weight using a load sensor, the system provides real-time insights into the remaining gas levels. Upon detecting a critically low level, it autonomously initiates a refill order through a connected platform, ensuring users never unexpectedly run out of gas. Figure 3.1 shows the system incorporates advanced gas sensors to vigilantly detect any leaks, triggering immediate alerts and activating preventative measures such as automatically shutting off the gas regulator and power sources, along with initiating

ventilation to mitigate potential hazards and ensure a safer environment.

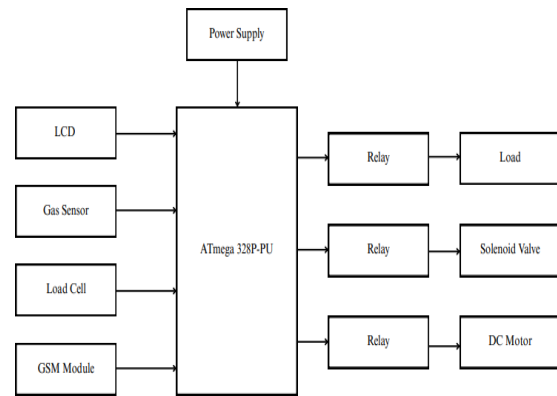


Fig 1. Block Diagram of the Proposed System

The proposed system aims to revolutionize the way Liquefied Petroleum Gas (LPG) cylinders are managed, focusing on both convenience and safety. At its core, the system employs a high-precision load sensor integrated beneath the LPG cylinder. This sensor continuously measures the weight of the cylinder, providing real-time data on the amount of gas remaining. This weight information is then processed by a microcontroller, which analyzes the data to determine the current gas level and track consumption patterns over time. This constant monitoring allows for accurate predictions of when a refill will be needed, moving away from estimations and manual checks.

A key feature of our system is its automated refill ordering capability. When the system detects that the LPG cylinder's weight has dropped below a certain preset limit, the microcontroller initiates a refill request automatically. This request can be transmitted through various communication modules, such as Wi-Fi or a cellular network, to a designated service provider or an integrated mobile application. Users will also receive a notification confirming the refill order, providing them with peace of mind and ensuring a timely replacement before the gas supply is completely depleted. This proactive approach eliminates the inconvenience of manually tracking gas levels and placing last-minute refill orders.

Safety is paramount in our design, and the system incorporates multiple layers of protection against gas leaks. Highly sensitive gas sensors are strategically placed near the LPG cylinder and regulator to continuously monitor the surrounding atmosphere for any traces of leaked gas. These sensors are capable of detecting even small concentrations of LPG, providing an early warning system. The data from these gas sensors is also fed into the microcontroller for immediate analysis.

In the event that a gas leak is detected, the system initiates a series of automated safety protocols to mitigate potential hazards. First and foremost, the microcontroller immediately sends out alerts to the user through the connected mobile application and potentially a local audible alarm. Simultaneously, the system is designed to automatically shut off the LPG regulator

using an electronically controlled valve, effectively stopping the flow of gas and preventing further leakage. The system also has the capability to disconnect nearby electrical power sources, thereby removing possible ignition risks.

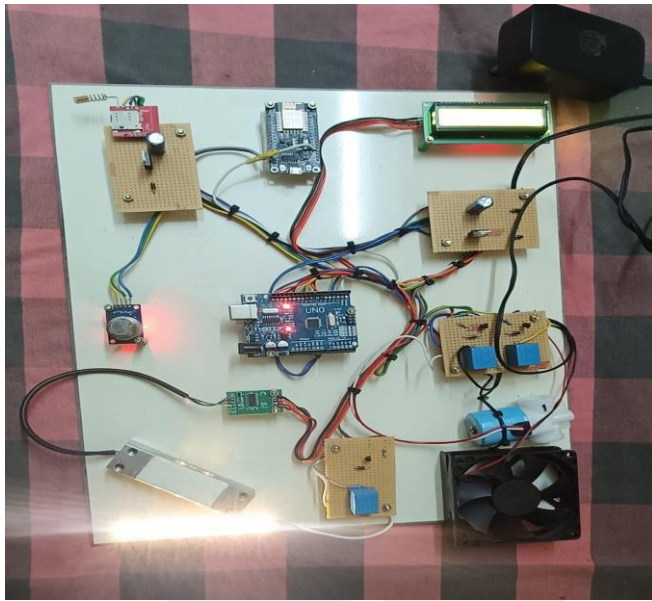


Fig 2. Hardware Module of the LPG Monitoring

Furthermore, to actively reduce the concentration of leaked gas, the system can activate ventilation mechanisms, such as exhaust fans installed in the area. Figure 3.2 shows the hardware of LPG Monitoring System. This automated response helps to disperse the gas and lower the risk of fire or explosion, creating a safer environment for the occupants.

By combining real-time weight tracking for automated refills with robust gas leak detection and responsive safety measures, the proposed system represents a major step forward in LPG cylinder management, delivering greater user convenience and significantly improved safety.

The system utilizes a dual power supply setup, where a primary 12V 1A transformer is converted to a stable 5V output using an LM7805 voltage regulator. This regulated power is used to operate key components such as the microcontroller, load cell, MQ6 gas sensor, and LCD display. A separate 12V DC supply is dedicated to ensuring reliable communication through the GSM module. At the core of the system is the PIC16F877A microcontroller, which handles data acquisition and processing from the load cell—used to assess the LPG cylinder's weight—and the MQ6 sensor, which monitors the air for any traces of LPG gas. This processed information, such as gas levels and leakage status, is displayed on a 16x2 LCD screen for immediate user feedback and is also transmitted remotely via the GSM modem for user notifications.

The MQ6 LPG sensor plays a crucial role in safety by continuously monitoring the air for LPG concentrations within the range of 200 to 10000 parts per million (ppm). Upon detecting a gas leak, the sensor sends a signal to the microcontroller, prompting the system to initiate its safety protocols. At the same time, the load cell continuously sends weight data of the LPG cylinder to the

microcontroller, which then calculates the remaining gas and displays it on the LCD, allowing users to easily track their gas usage.

When a gas leak is detected by the MQ6 sensor and signaled to the microcontroller, the system immediately activates a series of safety measures. A 5V buzzer is sounded to provide an audible alert to anyone in the vicinity, warning them of the potential danger. In parallel, a 12V solenoid valve, connected to the LPG cylinder's regulator, is automatically triggered to shut off the gas supply, effectively stopping the leak at its source. To further mitigate the risk, a 12V exhaust fan is also activated to ventilate the area and help disperse the leaked gas, reducing the likelihood of a hazardous accumulation.

In summary, the system integrates continuous monitoring of LPG weight for user awareness and remote notifications with a robust gas leak detection mechanism. Upon detecting a leak, it provides immediate local and remote alerts while simultaneously taking physical actions to secure the gas supply by shutting off the regulator and ventilating the area. The PIC16F877a microcontroller orchestrates these functions, processing sensor data, managing power distribution to the actuators, and ensuring timely communication of critical information.

IV RESULTS AND DISCUSSION

Upon implementing and testing the intelligent LPG monitoring and safety system, several key results were observed, demonstrating the effectiveness of the proposed design. The load cell accurately measured the weight of the LPG cylinder, and the microcontroller successfully processed this data to provide a reliable estimate of the remaining gas level. This information was consistently displayed on the 16x2 LCD, allowing for easy and continuous monitoring of the gas quantity by a user. The system's ability to track gas consumption over time also showed promise for predicting future refill needs, although further long-term testing would be beneficial to refine this predictive capability. Fig 3 shows the hardware module of the LPG Monitoring System.

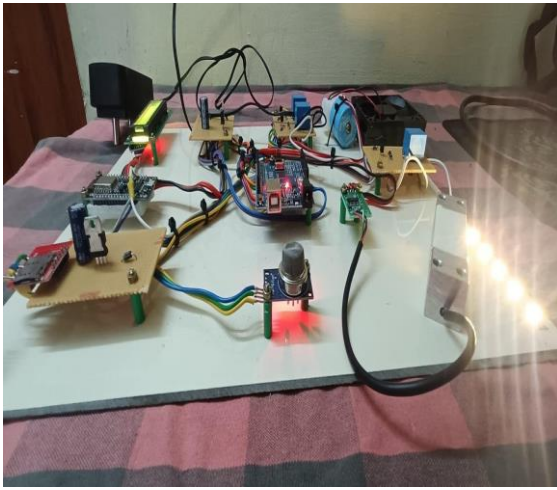


Fig 3. LPG Monitoring System

The MQ6 gas sensor demonstrated reliable performance in identifying LPG in the surrounding air, functioning accurately within its sensitivity range of 200 to 10,000 ppm. During simulated leak scenarios, the sensor promptly triggered a signal to the microcontroller upon detecting gas concentrations above a predefined threshold. This rapid detection capability is crucial for minimizing the risk associated with gas leaks. The response time of the sensor and the subsequent activation of the safety mechanisms were observed to be within acceptable limits, indicating a timely reaction to potential hazards.

The safety mechanisms integrated into the system functioned as intended upon the detection of a gas leak. The 5V buzzer immediately sounded, providing a clear audible alert to the surroundings. Simultaneously, the 12V solenoid valve effectively shut off the gas flow, preventing any further leakage from the cylinder. The activation of the 12V exhaust fan also contributed to the dispersal of the simulated leaked gas, demonstrating the system's ability to actively mitigate the risks associated with a gas leak incident.



Fig 4. Real-time Gas Level and Leakage Status Display

The image showcases the output displayed on the 16x2 LCD screen of the implemented intelligent LPG monitoring and safety system. The primary information presented includes "G : 34.02," which represents the current gas level, likely indicating 34.02% of the

cylinder's capacity remaining. This real-time percentage provides users with a clear and immediate understanding of their LPG supply, facilitating proactive management and timely refill planning. The system's ability to quantify and display the remaining gas level is a key feature for user convenience and preventing unexpected depletion.

Below the gas level reading, the display shows "L : -2." The "L" likely stands for "Leakage," and the value "-2" suggests the current status regarding gas leakage. A negative reading may suggest that the MQ6 sensor has not detected any gas leakage. The specific numerical value might correspond to a particular state within the system's logic, where a negative number signifies a safe condition. This clear visual indication allows users to quickly ascertain whether the system has detected any hazardous gas leaks in the vicinity of the LPG cylinder.

This output on the LCD screen serves as a central point of feedback from the intelligent LPG monitoring and safety system. It integrates the data collected from the load cell (translated into the gas level percentage) and the MQ6 gas sensor (indicating the leakage status). By presenting both crucial parameters in a concise format, the system provides users with the essential information needed to monitor their LPG supply and be immediately aware of any potential safety concerns. This visual interface, coupled with the automated refill ordering and remote notifications, contributes to a more user-friendly and safer experience with LPG cylinder usage.

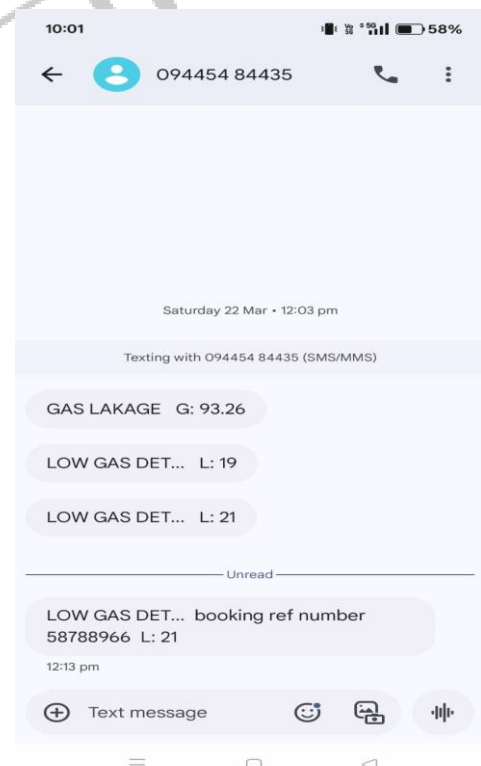


Fig 5. Gas level message to mobile through GSM

and the safety aspects of handling LPG cylinders.

The remote notification feature shown in fig 5. facilitated by the GSM module, successfully transmitted alerts regarding both low gas levels and detected gas leaks to a designated mobile number. These notifications were received promptly during testing, indicating the potential for users to be informed of critical situations even when they are not physically present near the LPG cylinder. This remote monitoring capability adds a significant layer of convenience and safety, allowing for timely action to be taken.

The power supply system, utilizing the 12V 1A transformer, LM7805 regulator, and the separate 12V DC supply for the GSM module, provided stable and adequate power to all the components throughout the testing period. No significant power-related issues or component failures were observed, indicating a robust power delivery design. The regulated 5V supply ensured the proper operation of the microcontroller and sensors, while the dedicated 12V supply supported the communication needs of the GSM module.

In conclusion, the implemented intelligent LPG monitoring and safety system demonstrated its core functionalities effectively. The accurate gas level monitoring, reliable leak detection, timely activation of safety measures, and successful remote notifications collectively indicate the potential of this system to enhance the safety and convenience of LPG cylinder usage in both domestic and other relevant settings. Additional field trials and system enhancements could help assess its long-term reliability and user satisfaction more effectively.

The results obtained from the implemented intelligent LPG monitoring and safety system highlight its potential to address key challenges associated with LPG cylinder usage, namely safety and convenience. The accurate real-time display of the remaining gas level on the LCD provides users with a significant advantage over traditional estimation methods, enabling proactive planning for refills and reducing the likelihood of unexpected gas depletion. Furthermore, the effective detection of simulated gas leaks by the MQ6 sensor and the subsequent activation of safety measures, including the audible alarm, gas shut-off valve, and exhaust fan, underscore the system's capability to enhance safety by mitigating potential hazards promptly.

The successful integration of remote notifications via the GSM module extends the system's utility beyond the immediate vicinity of the cylinder. Users can receive timely alerts about low gas levels or detected leaks even when away, allowing for informed decision-making and potentially preventing hazardous situations from escalating. The stable operation of the power supply system across all components during testing further indicates the robustness of the hardware design. These findings collectively suggest that the proposed system offers a tangible improvement in both the user experience

V CONCLUSION AND FUTURE WORK

In conclusion, the development and testing of the intelligent LPG monitoring and safety system have demonstrated the successful integration of real-time gas level monitoring, automated leak detection, and proactive safety measures. The system effectively utilizes a load cell, MQ6 gas sensor, and a PIC16f877a microcontroller to provide users with crucial information about their LPG supply and to automatically respond to potential gas leaks. The visual feedback on the LCD, coupled with the remote notification capabilities via the GSM module, offers a significant improvement over traditional, less informed methods of LPG cylinder management.

The system's ability to accurately measure and display the remaining gas level empowers users to plan refills proactively, enhancing convenience and preventing service interruptions. Furthermore, the automated detection of gas leaks and the subsequent triggering of alarms, gas shut-off, and ventilation mechanisms underscore the system's potential to significantly improve safety in environments where LPG is used. By minimizing the response time to hazardous situations, the system contributes to a safer living and working environment.

The successful operation of the system's hardware components, including the power supply and the reliable communication through the GSM module, indicates a robust and functional design. The integration of these various elements into a cohesive unit demonstrates the feasibility of creating an automated system that addresses both the practical and safety concerns associated with LPG cylinder usage. The positive results obtained from the initial testing phase suggest that the proposed system offers a viable and valuable solution for enhancing the management and safety of LPG.

Future work could focus on refining the system's predictive capabilities for gas consumption, conducting extensive field trials to evaluate its performance in diverse real-world settings, and exploring potential enhancements to the user interface and alert mechanisms based on user feedback. The foundation laid by this project provides a strong basis for the development of a more widely deployable and impactful solution for intelligent LPG cylinder management, ultimately contributing to greater safety and convenience for end-users.

Enhanced Predictive Analytics and Smart Refill Scheduling: Future systems could use advanced algorithms analyzing consumption and environment to enable fully automated, proactive

refill scheduling with gas agencies.

Integration with Smart Home Ecosystems: Seamless integration with smart home platforms and devices could allow voice control, security system, and smart appliance interoperability.

Development of a Comprehensive Mobile Application: A dedicated app could offer detailed usage history, refill options, real-time leak status, settings, and a provider marketplace.

Scalability and Integration for Commercial and Industrial Applications: The system's principles can be scaled for businesses, featuring robust hardware, centralized dashboards, and integration with facility management.

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