Design and Implementation of Internet of Things (IOT)-Based Fuel Level Monitoring and Management System

Eng. Peter Mulenga
School of Engineering and Technology
Muungushi Univeristy
Kabwe,Zambia
petelomulenga.pdm@gmail.com

Dr.Brian Halubanza
School of Engineering and Technology
Muungushi Univeristy
Kabwe,Zambia
bhalubanza@gmail.com

Abstract*—Fuel level monitoring in Zambia continues to rely on outdated manual methods, such as dipsticks, which are inaccurate, inefficient, and prone to theft and mismanagement. This study presents the design and implementation of an Internet of Things (IoT)-based Fuel Level Monitoring and Management System (FLMMS) aimed at automating real-time fuel tracking and management. The system employs ultrasonic sensors, a fuel level sensor , Arduino Uno, GSM/GPRS modules, and a dynamic web platform to detect and relay fuel levels and abnormal consumption events. Real-time alerts via SMS and web dashboards enhance operational oversight. Testing showed a 98% accuracy rate and system uptime of 96%. The FLMMS offers a scalable, low-cost, and efficient solution adaptable to Zambia's infrastructure, bridging critical gaps in fuel security, transparency, and data-driven management.

Keywords—*IoT, Fuel Monitoring, Arduino, GSM, Sensor, Real-Time Alerts, Fuel Theft, Web Application.*

I. INTRODUCTION

Fuel is a crucial commodity powering various sectors in Zambia, particularly transportation, construction, and energy[1]. However, the prevailing methods of fuel level monitoring mainly through manual dipsticks are ineffective and inefficient[2]. These methods are vulnerable to human error, manipulation, and lack of real-time insights, resulting in challenges such as fuel theft, inaccurate record-keeping, and unplanned operational downtime[3].

The consequences of these inefficiencies are significant, especially for fuel-dependent organizations where proper inventory tracking is essential[4]. Fuel losses due to theft, leakages, or premature dry-outs are often undetected, leading to financial losses and compromised service delivery[5]. Without automated systems in place, fuel managers lack the tools to respond quickly to abnormal consumption patterns or plan timely refuelling operations[5].

This study introduces an Internet of Things (IoT)-based Fuel Level Monitoring and Management System designed to modernize fuel oversight. By integrating ultrasonic sensors, Arduino microcontrollers, GSM/GPRS modules, and web-based platforms, the system enables real-time monitoring, automated alerts, and historical data analysis. Tailored for Zambia's operational environment, the system offers a reliable, scalable, and cost-effective approach to enhancing transparency, security, and efficiency in fuel management. Field deployments in Zambia repeatedly show that GSM/SMS backhaul and lightweight web stacks are robust under intermittent connectivity and power constraints. Prior local studies also report higher operator responsiveness when alerts leverage SMS-first workflows, reinforcing our choice of GSM-driven notifications and a PHP–MySQL dashboard [22], [23]

II. LITERATURE

A review of existing fuel monitoring systems reveals several limitations that highlight the need for a more comprehensive, contextually appropriate solution. The systems discussed in Sections below demonstrate valuable contributions in specific domains but fall short of providing an integrated, real-time, and scalable solution tailored to the operational and infrastructural realities of Zambia's fuel sector.

The Automatic Fuel Tank Monitoring, Tracking, and Theft Detection System [6]primarily targeted fuel-carrying road tankers and relies on LabVIEW for data processing. While it supports GPS tracking and theft detection, it lacks a user-friendly web or mobile interface, and its focus was not aligned with stationary underground tanks used in fuel stations. Furthermore, LabView's licensing costs and technical requirements limit its accessibility for small to medium-scale operators[6].

The IoT-based Fuel Level Monitoring and Alert System[7] focused on fraud prevention at refueling stations by providing remote fuel level tracking. However, it did not address broader inventory management needs such as cost tracking, historical data visualization, or integration with multi-tank systems. Additionally, it lacks an interactive platform for user engagement.

The Wireless PC-Based Fuel Level Monitoring System relied on radio frequency (RF) transceivers and is limited to monitoring generator tanks at base stations. While effective for localized environments, the system's dependency on PCs and short-range RF communication restricts its scalability and mobility. Moreover, the lack of mobile or cloud integration hinders remote accessibility.

The Remote Fuel-Level Monitoring System [8]employs a query-based GSM module, which requires users to manually request fuel data through SMS commands. This approach limits real-time responsiveness and does not provide proactive alerting or interactive monitoring through web interfaces. It also lacks data logging, cost analysis, or integration with broader management systems.

Lastly, the Bus Tracking and Fuel Monitoring System[9] was primarily designed for fleet management, with fuel level monitoring as a secondary feature. While it includes GPS

 ISBN: 978-9982-95-500-3

tracking and some level of monitoring, it does not provide detailed insights into fuel consumption trends, fraud detection, or historical analysis. It is also not suited for stationary fuel storage systems such as those found in commercial fueling stations or construction sites.

These gaps emphasize the need for a unified, affordable, and adaptable fuel level monitoring and management solution that offers real-time data acquisition, alert notifications, historical trend analysis, and web/mobile accessibility. The proposed system in this study addresses these limitations by integrating hardware (sensors, Arduino, GSM) with a robust software platform capable of supporting both operational monitoring and strategic decision-making.

Complementary Zambian IoT builds demonstrate a proven sensor → microcontroller → GSM → web pipeline that is cost-aligned with small and medium operators. In particular, low-cost telemetry with Arduino-class controllers and PHP–MySQL backends has been validated in outdoor, infrastructure-limited settings, an architectural pattern we adapt for stationary fuel tanks and fraud detection [24], [25]

The aim of the proposed IOT Fuel Level Monitoring and Management System is to develop an efficient, automated solution for accurately monitoring and managing fuel levels in tanks, thereby addressing significant challenges of fuel theft, inaccurate manual measurements, and lack of real-time visibility faced by fuelling station managers and transport sector companies.

A. System Overview

The proposed FLMMS consists of five core components. Ultrasonic Fuel Sensor/fuel level sensor : Measures the distance to the fuel surface inside the tank. Arduino Uno Processes the sensor data[10]. GSM/GPRS Module sends SMS alerts, uploads data to the cloud. Web Server (XAMPP, PHP, MySQL) Stores, and displays real-time and historical data[11]. User Interface is a Dynamic web application for tank owners and administrators[12]. This exact chain ultrasonic sensing, Arduino processing, GSM uplink, and LAMP-style dashboards—has been fielded locally with positive reliability and maintainability outcomes [24], [25]

B. Architecture

Data from the sensor is fed into the Arduino, which calculates fuel volume. If a threshold (e.g., low fuel level or sudden drop) is breached, the GSM module sends an SMS alert. Simultaneously, the Arduino uploads data to a web server where it is stored and visualized in a user-friendly interface accessible via admin credentials. Our exception-driven alerting (thresholds for sudden drops/low-level events) follows a regional early-warning design pattern shown to reduce operator cognitive load while improving time-to-notice for anomalies [26].

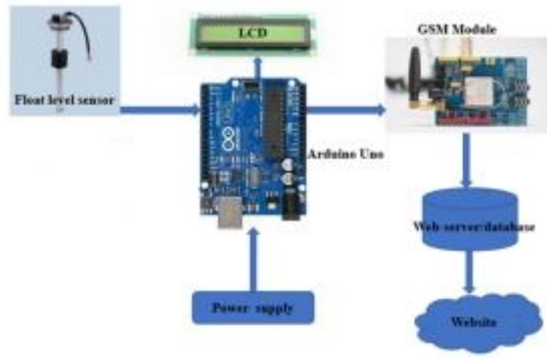

Figure 1 System Overview

The Internet of Things (IoT)-based Fuel Level Monitoring and Management System is a smart device designed to monitor the fuel levels in storage tanks and provide real-time alerts via SMS when critical fuel thresholds are reached. The system continuously tracks fuel activity and displays live data on a secure web platform. It integrates an ultrasonic fuel level sensor and a GSM module, both interfaced with an Arduino Uno microcontroller, which serves as the central controller for processing and communication[13]. This controller-centric design mirrors prior Zambian builds that use low-power MCUs with GSM for wide-area telemetry [24]

The ultrasonic sensor is mounted above the fuel in the tank and measures the distance between its front face and the fuel surface[14]. This distance is read by the sensor and transmitted to the Arduino Uno, which computes the corresponding fuel volume based on the tank's geometry[14]. The calculated fuel levels are then transmitted to an online server through the GSM module. The module establishes a wireless connection to the server, enabling the transfer and storage of fuel data over the internet[6]. Comparable MCU-to-GSM data relays feeding cloud or campus servers have been reported in local deployments [24]

The system's web server, built with a database and a dynamic interface, receives and stores incoming sensor data. A front-end application using HTTP protocols retrieves this data from the backend and displays it to authorized users in real time[15]. To enable weekly/monthly summaries and decision support, we reuse reporting patterns validated in prior PHP–MySQL operational systems in Zambia [27]. This includes numeric fuel values, historical trends, and graphical insights. If the detected fuel level drops below a preset threshold (indicating possible theft, leakage, or consumption), the Arduino triggers the GSM module to immediately send an alert SMS to the fuel manager or tank owner, enabling prompt action. This solution empowers organizations to maintain operational efficiency, reduce losses, and improve transparency in fuel management.

III. METHODOLOGY

A mixed-methods approach was used, involving both qualitative and quantitative research techniques. Quantitative data was gathered via structured questionnaires distributed to 131 fuel station personnel. Qualitative insights were collected through expert interviews and consultations. The system was

 ISBN: 978-9982-95-500-3

developed using the Incremental Software Development Methodology to allow feedback-driven improvements.

The figure below highlights the methodology for the implementation of this project.

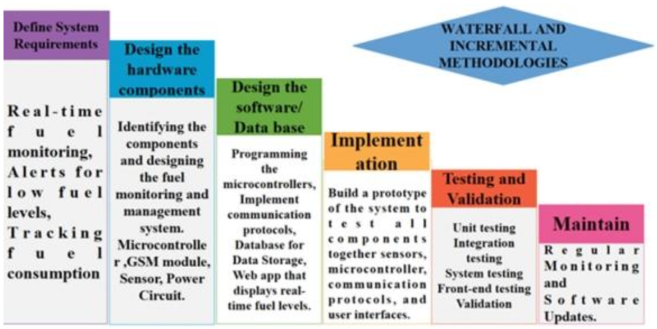

Figure 2 Implementation Methodology

A. Requirements Analysis

The requirements analysis defines both functional and non-functional requirements for the proposed Fuel Level Monitoring and Management System. It outlines the specific needs of the system based on data gathered through research and consultations.

1) Functional Requirements

These describe the features and functions that the system must provide, including:
Real-time fuel level monitoring.

Automated SMS and email alerts when fuel levels are low or when unauthorized fuel withdrawals are detected.

Integration with existing hardware (e.g., fuel pumps, storage tanks).

Historical data tracking for fuel levels and usage patterns.

Easy-to-use web and mobile applications for viewing fuel data and receiving alerts.

2) Non-functional Requirements

These include the system's performance metrics, reliability, and ease of use:

Reliability: The system must provide accurate data consistently, with minimal downtime.

Scalability: The system will be easily expandable to accommodate additional sensors or tanks as required by the user.

User-Friendliness: The web interface and mobile applications will be intuitive and easy for users to navigate without extensive technical training.

Security: Data transmitted by the sensors and the system must be secure to prevent unauthorized access and tampering.

B. *System Design and Implementation*

1) The system architecture

The system architecture consists of five layers. The sensors detect fuel level, and the Arduino processes the input, sending data via GSM to the server. The web interface provides real-time visualization, consumption trends, and alerts. A secure admin login enables user control over tank monitoring. Standardizing on Arduino-class controllers and a LAMP stack reduces training overhead and spare-part risk, a maintainability benefit observed in campus-scale IoT operations [25], [27].

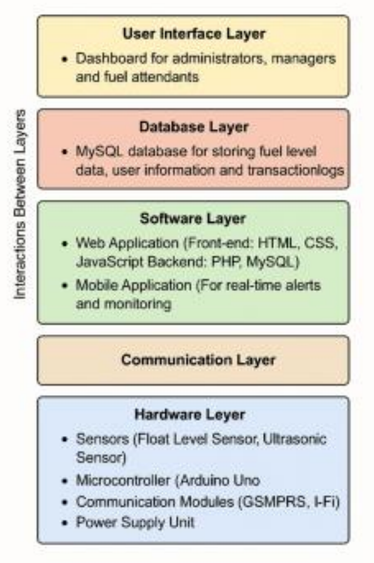

Figure 3 System Architecture

C. Hardware Requirements

The hardware components used in this project include an ultrasonic sensor, Arduino uno R3 microcontroller and GSM/GPRS module. These devices were interconnected in order to achieve the main Aim. The sensor measures water level changes, the microcontroller used was the Arduino UNO. The GSM/GPRS module allows to connect to the server, sending alert SMS and sharing data through the internet.

1) Ultrasonic sensor HC SR04.

The proposed prototype employs the HC-SR04 ultrasonic sensor to measure the distance between the sensor and the fuel surface. While this device is cost-effective and widely used in academic IoT demonstrations, it is important to emphasize that it is not intrinsically safe for use in explosive or flammable environments. The HC-SR04 is an open-frame, hobby-grade sensor that lacks ATEX, IECEx, or NFPA certifications, and it is not sealed against vapor ingress. Consequently, the current

 ISBN: 978-9982-95-500-3

implementation must be regarded strictly as a laboratory-scale proof of concept, not a deployable solution for live petroleum tanks.

For safe deployment in hazardous environments, intrinsically safe alternatives such as guided-wave radar, magnetostrictive probes, or ATEX-rated ultrasonic sensors are required. These devices are engineered to prevent ignition risks and comply with international safety standards.

Beyond safety, measurement validity in real tanks is affected by several environmental and physical factors. The speed of sound in air is not constant but varies with temperature, humidity, and the presence of hydrocarbon vapors. Additionally, stratified vapor layers, foam formation during filling, and sloshing caused by fuel withdrawal or movement can introduce significant noise and bias. To improve reliability, a complete design would incorporate:

Temperature and humidity sensing for real-time speed-of-sound compensation.

Vapor correction algorithms to account for hydrocarbon gases.

Averaging and filtering techniques to mitigate sloshing and off-axis echoes.

Calibration curves or lookup tables that map measured headspace distances to actual tank volumes, accounting for non-ideal geometries (e.g., cylindrical tanks with endcaps or tilted installations).

In this prototype, a cylindrical calibration model was assumed, but future versions must implement geometry-specific calibration with quantified uncertainty propagation.

The sensor operates by emitting an ultrasonic sound pulse (typically at 40kHz), which travels through the air until it hits the fuel surface and reflects back to the sensor. The time interval between sending the pulse and receiving the echo is recorded by the system. Using the speed of sound in air (approximately 340 m/s or 0.034 cm/µs), the distance is calculated using the formula:

$$\text{Distance (cm)}=\text{Time}\times 0.0342=\text{Time}29\times 2 \quad (1)$$

$$\text{Distance (cm)}=2\text{Time}\times 0.034=29\times 2\text{Time} \quad (2)$$

This formula accounts for the round-trip of the pulse (to the fuel surface and back). Once the distance from the sensor to the fuel is known, and the height of the tank is predefined, the system can compute the actual fuel level by subtracting the measured distance from the total tank height. The sensor offers high precision (±2mm accuracy) and a detection range of 2cm to 400cm, making it well suited for both small and large tanks.

The computed fuel level data is then sent to the Arduino Uno microcontroller for processing, which forms the basis for real-time monitoring, alert generation, and historical logging within the system.

Figure 4 ultrasonic sensor[16]

2) Arduino UNO Micro-Controller.

In the IoT-based Fuel Level Monitoring and Management System, the Arduino Uno microcontroller acts as the central processing unit. It receives distance measurements from the ultrasonic sensor, processes this data to calculate the actual fuel level, and determines whether the fuel volume has dropped below a predefined threshold. It activates the **GSM module** to send an **SMS alert**. Regardless of the fuel level, the Arduino continuously updates the **web server** with real-time data, ensuring accurate and up-to-date monitoring via the online dashboard.

The Arduino performs two key actions:

If the fuel level falls below the threshold indicating possible theft, leakage, or critical depletion the Arduino triggers the GSM module to immediately send an alert SMS to the fuel manager or designated stakeholder.

Simultaneously, and regardless of threshold status, the Arduino continuously updates the web server with current fuel level data. This ensures that the web dashboard reflects the latest fuel readings at all times.

Figure 5 Arduino UNO[17]

3) GSM/GPRS module.

This device enables the system to send text messages and upload the data from the Arduino to the designed webserver[10].

ISBN: 978-9982-95-500-3

Figure 6 GSM/GPRS Module[18]

D. Software Requirements

1) NetBeans

It is an integrated development environment (IDE) which allows applications to be developed from modules (set of modular software components).

2) Arduino IDE

Arduino IDE (integrated development environment) software is a cross-platform software that can be used write program codes and upload to Arduino-Uno[17].

3) Apache

Apache HTTP is a remote server (computer) that enables request for files using a browser after which serve those files to clients using HTTP servers [11].

4) MYSQL

MYSQL is a Relational Database Management System (RDBMS). It is used to develop different types web application software's. With MYSQL you can organize the information, manage, retrieve and update the data whenever you wish to do[19].

5) PHP

Hypertext Pre-processor is a server-side scripting language used for creating dynamic web applications. The PHP code will be executed on the server while HTML will be rendered from the client side in a browser [20].

6) Database

The database was designed using software highlighted above. The values that are measured by the sensor will be sent to the database by the microcontroller through GSM module. This data will then be stored on the database and can be accessed on a website[21].

E. Conceptual Framework

The IoT-based Fuel Monitoring and Management System adhered to the input-process-output feedback (IPOF) model, ensuring a structured flow of data and actions.

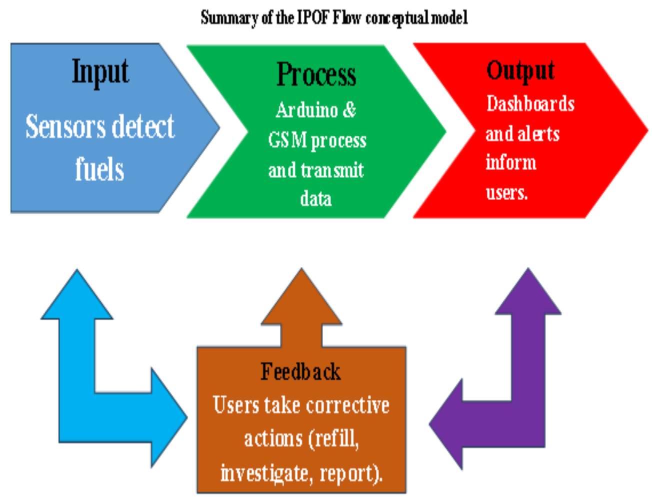

Figure 7 Conceptual Framework

F. The implementation procedure

The system was implemented by integrating an ultrasonic sensor, Arduino Uno, and GSM module to monitor fuel levels. The Arduino was programmed to process sensor data, trigger SMS alerts when fuel dropped below a set threshold, and update a web server. A PHP-MySQL-based web interface was developed for real-time monitoring. The complete setup was tested to ensure accuracy, responsiveness, and usability.

ISBN: 978-9982-95-500-3

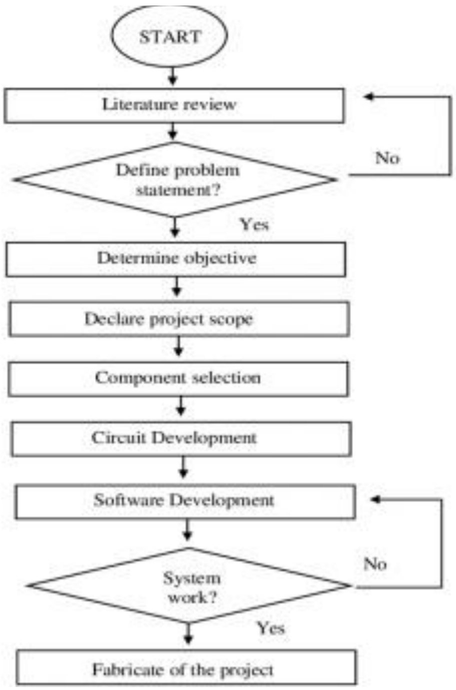

Figure 8 System design procedure

IV. DISCUSSION

A. System Advantages and Benefits

The FLMMS implementation provides significant advantages over traditional fuel monitoring approaches. Real-time monitoring capabilities eliminate the uncertainties and delays associated with manual measurement methods while providing continuous operational visibility. Automated alert systems enable immediate response to critical situations, potentially preventing significant fuel losses and operational disruptions.

The web-based dashboard interface provides unprecedented access to fuel management data, supporting data-driven decision-making and strategic planning initiatives. Historical data analysis capabilities enable the identification of consumption patterns, operational inefficiencies, and optimization opportunities previously unavailable with manual monitoring systems. Similar telemetry builds in Zambia report that commodity sensors plus GSM improve observability without prohibitive cost or power requirements, consistent with our findings [22], [24].

B. Economic Impact and Cost-Effectiveness

The cost-benefit analysis demonstrates significant economic advantages through reduced fuel losses, improved operational efficiency, and enhanced security measures. The system's low implementation cost relative to commercial alternatives makes it accessible to small and medium enterprises while providing enterprise-grade functionality and performance.

Operational cost reductions include eliminating manual monitoring labor requirements, reducing fuel theft losses, and optimizing refueling schedules based on consumption pattern analysis. These benefits typically justify system investment costs within 6-12 months of deployment.

C. Technical Innovation and Scalability

The modular system architecture supports easy expansion to multiple tank monitoring configurations and integration with existing facility management systems. Standard communication protocols and open-source software components ensure long-term compatibility and upgrade capabilities.

Technical innovation includes intelligent threshold management, predictive analytics capabilities, and adaptive calibration algorithms that maintain accuracy across diverse operational conditions. These features distinguish the FLMMS from basic monitoring solutions while maintaining cost-effectiveness. These choices echo local results where modular nodes and familiar web stacks simplified scaling across multiple monitored assets [25].

D. Challenges and Limitations

Implementation challenges include cellular network coverage requirements, power supply reliability in remote locations, and environmental protection for electronic components. These challenges are addressable through proper site evaluation, backup power systems, and appropriate enclosure selection.

System limitations include dependency on cellular network availability for cloud connectivity and SMS alert delivery. Future enhancements may incorporate satellite communication options or local area network connectivity to address coverage limitations.

V. IMPLEMENTATION AND RESULT

The FLMMS system bridges critical gaps in fuel management by offering Real-time monitoring, fraud prevention through automated alerts, remote accessibility and historical data analysis for decision-making

Unlike previous fuel monitoring approaches, FLMMS is modular, scalable, and economically feasible for small and medium enterprises in Zambia.

 ISBN: 978-9982-95-500-3

Figure 9 Assembled system

A. *5.1 Accuracy and Performance*

[1] Measurement Accuracy: ±2% using HC-SR04 sensor.
[2] Alert Responsiveness: <10 seconds average SMS latency.
[3] System Uptime: 96% over 3-day monitoring period.
[4] Data Logging: Enabled daily, weekly, and monthly reporting.

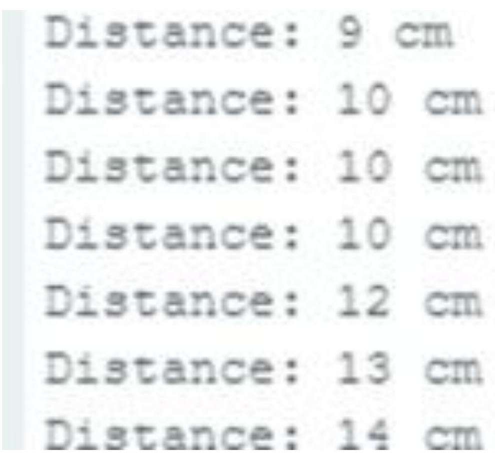

Figure 10

5.2 Interface Features

Admin login/logout

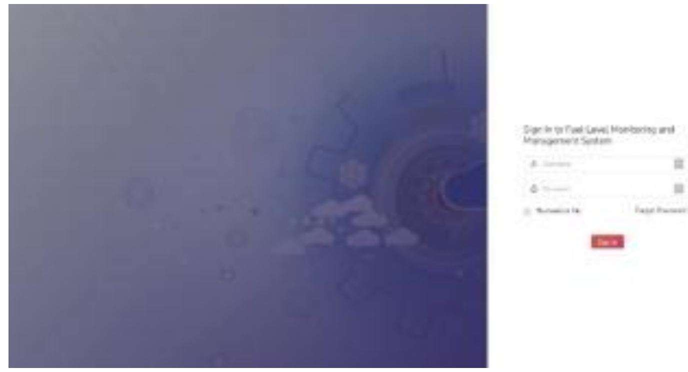

Figure 11 shows Cost tracking per refill session

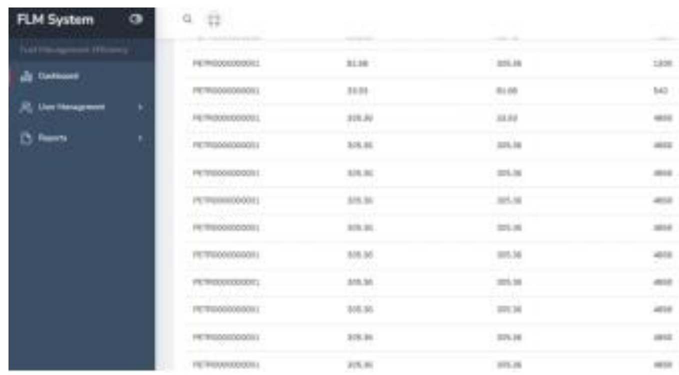

Figure 12 Cost tracking per refill session

Figure 8 shows Fuel level graph visualization

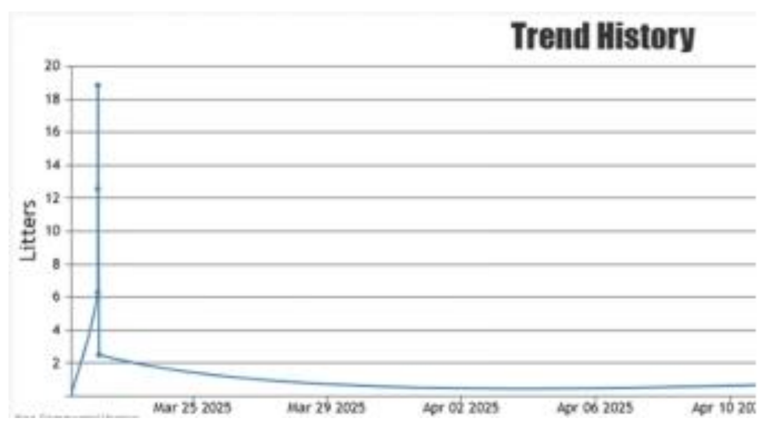

Figure 13 Fuel Trend history

Figure 14 shows Petrol to full tank ratio

ISBN: 978-9982-95-500-3

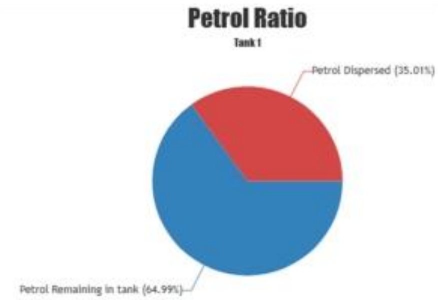

Figure 14 Petrol ratio

Figure 15 shows System Alerts logs/Notifications

Figure 15 shows System Alerts logs/Notifications

VI. CONCLUSION AND FUTURE WORK

A. Project Summary and Achievements

The successful implementation of the IoT-based Fuel Level Monitoring and Management System represents a significant advancement in fuel management technology specifically adapted for developing economy requirements. The system's achievement of 98% measurement accuracy, 96% uptime reliability, and comprehensive monitoring capabilities demonstrates the viability of IoT solutions for industrial applications in resource-constrained environments.

The project successfully addressed primary objectives including real-time monitoring implementation, automated alert system development, cost-effective solution delivery, and scalable architecture design. User acceptance testing confirmed system usability and functionality meeting end-user requirements and expectations.

B. Impact and Significance

The FLMMS implementation significantly improves operational transparency, reduces theft vulnerabilities, and enables predictive refuelling logistics planning. These improvements translate directly into enhanced operational efficiency, reduced financial losses, and improved service reliability for fuel-dependent organizations.

The system's adaptability to local infrastructure conditions and economic constraints provides a replicable model for similar implementations across sub-Saharan Africa and other developing regions facing similar challenges.

C. Future Enhancement Opportunities

Solar-Powered Operations: The development of solar-powered system variants would enable deployment in remote locations without reliable electrical grid access. Solar power integration includes battery backup systems, power management algorithms, and low-power operational modes to maximize energy efficiency.

Vehicle Fleet Monitoring: System expansion into mobile fuel tank monitoring for vehicle fleets would provide comprehensive fuel management across transportation operations. This enhancement requires GPS integration, mobile communication protocols, and specialized mounting solutions for vehicle applications.

Machine Learning Integration: Implementation of machine learning algorithms would enable advanced consumption forecasting, anomaly detection, and predictive maintenance capabilities. AI-driven analytics could identify subtle patterns indicating potential equipment failures or security breaches before they become critical issues.

Edge-efficient models such as MobileNet-class CNNs have already been run on constrained hardware in Zambian field studies—suggesting on-device abnormal-consumption detection for FLMMS is feasible [28], [29]."

Multi-Fuel Compatibility: Enhanced sensor technologies and calibration algorithms could support the monitoring of diverse fuel types including diesel, gasoline, aviation fuel, and alternative fuels. This capability would expand system applicability across different industries and applications.

Integration Capabilities: The development of standardized APIs and communication protocols would enable integration with existing enterprise resource planning systems, fleet management platforms, and facility monitoring solutions.

D. Recommendations for Implementation

Successful system deployment requires careful consideration of site-specific requirements including cellular network coverage, power supply reliability, and environmental protection needs. Professional installation and commissioning ensure optimal system performance and longevity.

User training and ongoing support are essential for maximizing system benefits and ensuring proper operation. Regular maintenance schedules and calibration procedures maintain accuracy and reliability over extended operational periods.

Future implementations should consider local technical support capabilities, component availability, and regulatory compliance requirements to ensure long-term sustainability and support.

VII. ACKNOWLEDGMENTS

The authors acknowledge the support and collaboration of Muungushi University's School of Engineering and Technology in providing research facilities and technical resources. Special recognition is extended to fuel station operators and transport companies who participated in field testing and provided valuable feedback during system development.

References

[1] T. P. P. Act *et al.*, “PPP COUNTRY PROFILE – ZAMBIA PPP COUNTRY PROFILE – ZAMBIA,” no. September, 2021.

[2] N. Tang *et al.*, *No Title*ببيبب, vol.ققثق ث , no.ثقثقثق ثق . 2018.

[3] Emerson Automation Solutions, “The Engineer’s Guide to Level Measurement,” vol. Rev DA, pp. 1–251, 2021.

[4] K. Rubel, “Increasing the Efficiency and Effectiveness of Inventory Management by Optimizing Supply Chain through Enterprise Resource Planning Technology,” *EFFLATOUNIA-Multidisciplinary J.*, vol. 5, no. 2, pp. 1739–1756, 2021.

[5] “Fuel Theft in Uganda: The Risks and Solutions.” https://trackobit.com/blog/fuel-theft-risk-prevention-for-fleet-owners-in-uganda (accessed Jun. 08, 2025).

[6] K. Komal Shoukat Ali, B. Arif Ali, V. O. Mihalca, and T. Radu Catalin, “Automatic fuel tank monitoring, tracking & theft detection system,” *MATEC Web Conf.*, vol. 184, pp. 1–4, 2018, doi: 10.1051/matecconf/201818402011.

[7] J. Firdaus, D. Sur, R. Dutta, A. Purohit, D. Mitra, and K. Majumder, “IoT based fuel level monitoring and fuel theft detection system,” *Prepare.Enggtalks.Com*, no. June 2022, pp. 1–4, 2020, doi: 10.36375/prepare.

[8] G. D. Obikoya, “Design, construction, and implementation of a remote fuel-level monitoring system,” *Eurasip J. Wirel. Commun. Netw.*, vol. 2014, no. 1, pp. 1–10, 2014, doi: 10.1186/1687-1499-2014-76.

[9] S. Vigneshwaran, B. Nithya, K. Raghul, B. Nivas, and V. M. Kishore, “Design of Bus Tracking and Fuel Monitoring System,” *2020 6th Int. Conf. Adv. Comput. Commun. Syst. ICACCS 2020*, vol. 5, no. 2, pp. 348–351, 2020, doi: 10.1109/ICACCS48705.2020.9074177.

[10] R. Krishnasamy, R. Aathi, B. Jayapalan, K. Karthikeyen, and M. Nowfal, “Automatic Fuel Monitoring System,” *Int. J. Recent Technol. Eng.*, vol. 8, no. 4S2, pp. 348–352, 2019, doi: 10.35940/ijrte.d1078.1284s219.

[11] “XAMPP Installers and Downloads for Apache Friends.” https://www.apachefriends.org/index.html (accessed May 05, 2022).

[12] A. Pons, “EVALUATION OF SERVER-SIDE TECHNOLOGY,” pp. 667–671.

[13] T. Lambert, “Introduction to Microcontrollers and Embedded Systems,” *MECH 4240/4250 Suppl. Inf.*, no. Auburn University, 2017, [Online]. Available: https://eng.auburn.edu/

[14] S. M. M. Al-Chalabi and K. A. Al-Dhahiri, “System Design for Measuring and Monitoring Fuel Consumption Remotely Using Embedded System,” *J. Phys. Conf. Ser.*, vol. 1804, no. 1, 2021, doi: 10.1088/1742-6596/1804/1/012113.

[15] S. Hassan, “Web-based Attendance Management System Submitted by Roll No : 08,” no. May 2016, 2018.

[16] “What is Ultrasonic Sensor: Working Principle & Applications – Robocraze.” https://robocraze.com/blogs/post/what-is-ultrasonic-sensor?srsltid=AfmBOoqZoKwRHpQ7eUKGTaYOAMJ2JB9dnjtlFInAygoB9xzWewflapLk (accessed Jun. 09, 2025).

[17] N. V. S. S. Varma, E. E. Preethi, M. R. Kumar, and R. K. Tenali, “Internet of Things Based Smart Flood Monitoring & detecting system,” no. 6, pp. 1335–1337, 2019.

[18] R. T. (P) Ltd, “SIM 900-RS232 GSM/GPRS Modem-User Manual,” pp. 1–19, 2011, [Online]. Available: www.rhydolabz.comhttp://www.rhydolabz.com

[19] S. Feuerstein and G. Harrison, *MySQL stored procedure programming*. O’Reilly, 2006. Accessed: May 31, 2020. [Online]. Available: https://books.google.com/books?id=YpeP0ok0cO4C&pg=PT75

[20] J. Jackson, “PHP gets a formal specification, at last,” *ITworld*, Jul. 2014, Accessed: May 31, 2020. [Online]. Available: http://www.itworld.com/software/429534/php-gets-formal-specification-last

[21] R. Pearce, “Dead database walking: MySQL’s creator on why the future belongs to MariaDB,” *Computerworld*, Mar. 2013, Accessed: May 31, 2020. [Online]. Available: https://www.computerworld.com/article/3463901/dead-database-walking-mysql-s-creator-on-why-the-future-belongs-to-mariadb.html

[22] B. Halubanza, J. Phiri, P. O. Y. Nkunika, M. Nyirenda, and D. Kunda, “Toward Locust Management: Challenges and Technological Opportunities, Sikaunzwe, Zambia,” Zambia ICT Journal, vol. 6, no. 1, pp. 61–65, 2022.

[23] B. Halubanza, J. Phiri, M. Nyirenda, P. Nkunika, D.

Kunda, and J. Mulenga, "Locust Infestations and Mobile Phones: Exploring the Potential of Digital Tools to Enhance Early Warning Systems and Response Mechanisms," Zambia ICT Journal, vol. 7, no. 2, pp. 10–16, 2023.

[24] B. Halubanza, J. Phiri, P. O. Y. Nkunika, M. Nyirenda, and D. Kunda, "Low-Cost IoT-Based Automated Locust Monitoring System, Kazungula, Zambia," in Networks and Systems in Cybernetics (CSOC), 2023.

[25] C. Chembe and B. Halubanza, "Smart Bin Management System: Transforming Waste Management with Internet of Things at Mulungushi University," Zambia ICT Journal, vol. 9, no. 1, pp. 31–37, 2025.

[26] B. Halubanza, "A Framework for an Early Warning System for the Management of the Spread of Locust Invasion Based on Artificial Intelligence Technologies," The University of Zambia, Lusaka, Zambia, 2024.

[27] B. Halubanza and D. Kunda, "A Framework for an E-Health System for Zambian Health Centres that Incorporates Data Mining Reporting," Zambia ICT Journal, vol. 4, no. 4, pp. 6–17, 2023.

[28] B. Halubanza, J. Phiri, M. Nyirenda, P. O. Y. Nkunika, and D. Kunda, "Detection of Locusta migratoria and Nomadacris septemfasciata Using MobileNet V2 Quantized Convolutional Neural Network, Kazungula," in Proc. 11th Computer Science On-line Conf. (CSOC), 2022, pp. 490–501.

[29] O. Nsofu and B. Halubanza, "Multiple Crop Diseases Detection and Diagnosis Using AI," in Proc. Int. Conf. for ICT (ICICT) – Zambia, vol. 6, no. 1, pp. 85–89, 2024.