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Development of a smart liquified petroleum gas stove with real-time protection and notification using IoT

(A Case Study of East Africa region' Domestic users)

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ABSTRACT

The world is advancing technologically in all sectors including the use gas as cooking energy. Liquefied Petroleum Gas (LPG) is one of the gases used for cooking. The use of LPG by cooking protects the environment against deforestation and air pollution. But people are not very comfortable using it due to some issues related to the manual frame regulation that sometimes cause fire sparks, manual switch and LPG cylinder explosion that are causing many accidents in daily life. The previous related works reviewed have provided some solutions like alerting notifying and closing the Gas flow while there is a Gas leakage and auto fire extinguisher system against the fire caused by that Gas. But still, those solutions did not help users to maximize the benefits of using that gas. This project aims to develop a smart Liquefied Petroleum Gas (LPG) stove powered by the integration of Internet of things (IoT) and Embedded Systems to auto-switch the stove, monitor the gas level, prevent the gas explosion and notify the user the state of the stove.

Key Words: Liquified Petroleum gas, Smart Stove, Mobile application, WiFi Protocol, Expressif Module.

1. INTRODUCTION

1.1 Background

Liquified petroleum gas(LPG) is one of the flammable gas that are being used as fuel gas in households for cooking and also for heating appliances, in many countries for economic reasons, for convenience, and also for environmental protection reasons compared with other kinds of cooking energy. In march 2020, 97.4 per cent of Indian households use LPG as either primary or complementary cooking fuel (Ministry of Petroleum and Natural Gas, 2020). This Gas is transmitted from the cylinder to the stove through pipe. It in a compressed form and stored as a liquid in a cylinder and it evaporates as a once realized out of the cylinder. Many reasons make the LPG to be among the best options for cooking energy namely that it has the lowest C02 emission compared to others gases such as gasoline and diesel fuel (Demirbas 2002). On the other hand, when we compare LPG with charcoal and firewood for cooking, we find that those two are the main causes of deforestation which cause the climate changes. Using the LPG has thus many health advantages and air pollution reduction.

Tanzania has started promoting the use of Liquified petroleum gas by relieving taxes to emphasize the transition from firewood and charcoal in households to LPG (Ministry for Energy and Minerals of Tanzania 2015). However, this type of gas can be very dangerous if it is used accordingly as long as it is flammable. Therefore, preventing its outflow, the detection of its volatilization, and the control of its consumption, are crucial. when using a gas cooker, the users sometimes forget to turn it off and the gas keeps on burning. (Milecki and Rybarczyk 2020) The lack of knowledge also causes many accidents while using LPG gas. As we move towards accessibility of clean cooking energy, integrating IoT technology to the use of LPG stoves will make it even more attractive and thus increase its use's attractiveness.

2. PROBLEM STATEMENT

The LPG provides the best option of cooking energy, but it has some issues which cause some people to fear using it due to the attention that it requires, guidelines that must be followed while using it. However, those requirements are a must so that this gas can't cause accidents that are normally appearing in our daily life. Sometimes it happens when the user cooks by using the gas

stove and after cooking forgets to turn off the switch then the gas keeps on burning without a saucepan on it (Milecki and Rybarczyk 2020). This issue in the end will cause all equipment in the surroundings to get burnt or the waste of the gas. They are other potential accidences that occur with LPG like gas leakage from various parts of the LPG cooking system, manual frame regulations that sometimes cause accidents. There are some existent solutions but they lack some features. Here we can name timed auto-switch. This project was mainly focused on the development of a smart LPG stove that can provide an auto-switch where users are enabled to interact with the gas stove physically via keypad, LCD, and buzzer and remotely through a mobile phone via mobile app and SMS. This stove is smart with the ability to monitor and control the whole cooking system, alerting and notifying the users where needed. The development of this smart stove combines the integration of embedded systems and Internet of things (IoT) technologies to enhance the confidentiality of users by producing the stove with friendly use and efficiency

3. OBJECTIVES

The main objective of this project is to develop a smart Liquified Petroleum Gas (LPG) stove that will enable auto switch and gas cylinder explosion prevention.

The specific Objectives were:

i. To identify the requirements
ii. To develop the smart LPG stove
iii. To validate the developed system

4 RESEARCH QUESTIONS

i. What are the main requirements for developing a Smart Liquefied Petroleum Gas stove?
ii. How should the Smart Liquid Field Petroleum Gas stove be designed and developed?
iii. How will the study ensure the developed system met the user requirements and fulfil the needs of stakeholders?

5 Conceptual Framework

Fig.1 below represents a conceptual framework model that guided the logical Functionalities of the development of smart liquefied petroleum gas stove with a real-time notification and prevention. A Mobile application links a networked Embedded Systems so that users can interact Physically and remotely with the stove.

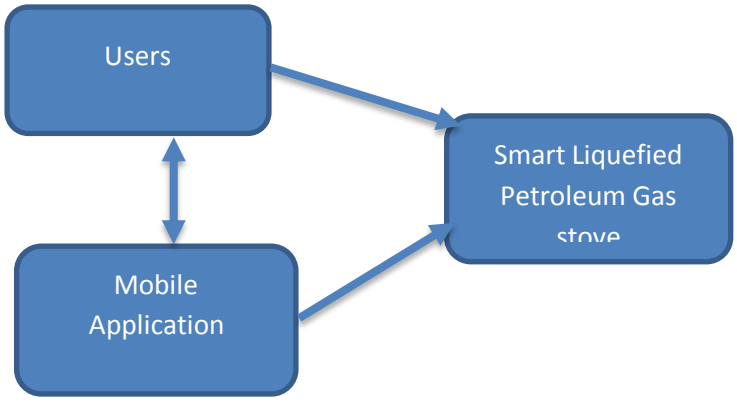

Figure 1. Conceptual Framework

5. SIGNIFICANCE OF THE STUDY

The implementation of the system is mostly significant as follow:

- To enable LPG users to get the confidence of daily use.
- To Monitor and Control the cooking system with physical and remote interaction.
- To economize the time and money used periodically while buying the LPG.
- To protect users against accidents.

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2. LITERATURE REVIEW

Engineers have proposed various solutions to make the use of LPG safe and efficient. The common objective is to improve the user experience and attract more people to adopt the LPG stove as it has been proven that LPG considerably reduces environmental pollution.

To increase the efficiency of the LPG gas stove [1]proposed a system capable of generating electricity from the cooking process. The system uses thermoelectric coolers (TEC) to transform the heat from the cooking process into electricity. Furthermore, the system has the MQ-6 gas sensor for detection of gas leakage and notification to the user is done via SMS. However, the system would be more efficient if it had a mechanism to automatically switch off the stove in case of gas leakage. Also, to produce more electricity from the cooking heat, the system should integrate a thermoelectric generator rather than.

A system for kitchen safety developed by [2] can monitor the presence of a person near the stove when it is on. The smart alert system is able to detect if a gas stove is left unattended while cooking. If there's no person detected, a periodic buzzer alert is emitted. If the user does not come back to the stove after a certain time, the system turns off the fire.

Another solution to increase the safety of cooking with LPG stoves has been created[3]. The aim of the authors is to deny a child to switch on the stove and notify the user in case of gas leakage. To achieve that video streaming in real-time, machine learning and deep learning are used to hinder children from turning on the stove. The user is also able to monitor the stove remotely. However, a GSM module should be added to allow the user to get notifications via SMS as a backup communication solution.

The dangers of keeping a gas fire without a pot on the burner have been tackled[4]. The system monitors the burner and automatically switches off the gas when the pot is removed. IR diode and thermocouple are used to detect post presence over the burner. However, the system should delay for a certain time because we can remove a pot to put another one. Moreover, the solution is not compact enough to fit into gas cooker systems.

Another solution created by [5] enables the user to check remotely the gas stove status whether it is on or off. The invented IoT-based system enables the user to continuously monitor through a mobile application the state of the stove. However, the system will be more useful with features like a timer and panic notification when the gas is on for a long time.

A system based on an ATmega328p microcontroller was created by[6]to improve safety and reduce wastage of gas. The system enables the stove to automatically release the gas when there is a flame and a pot on the burner. The fan starts to operate when there is a detection of smoke. The system has also a timer that switches the system off when the time is over. Furthermore, a voice controlling system of the burner is integrated into this system. When there is a gas leakage an alarm is activated and the user is alerted through a call or text message. However, to enable remote access, the system should enable internet access to the system.

[7] proposed a system capable of detecting gas leakage and notifying the user via LoRa communication technology. The police station is also alerted when danger is detected. To avoid further damage, the main electricity switch of the home is deactivated and the fan activated. The heat from cooking is used to generate electricity. However, the solution should include a mechanism of management of data from LoRa. Potentially connect all smart stoves in the country to enable the government to implement a prepaid gas meter for the population.

3. MATERIALS AND METHODS

3.1. Area of the Study and Scope

This study will be conducted in Dar-es-Salaam and Arusha, Tanzania. We will need Dar es salaam to interact with LPG cylinder manufacturers so that we can come up with the standards with high efficiency. We will also collect data in Arusha by interacting with households so that we could come up with useful requirements from users and this study will allow us to understand more about the challenges that the users of LPG are facing and try to resolve them using embedded systems.

3.2. Data Collection method

The data was collected from the Arusha Region and the Institution's Hostels by using a observation and face to face interviews that enabled us to interact with stakeholders deeply so that we can develop a useful system.

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3.3. System development Approach

The project will adopt an AGILE development methodology. We have chosen AGILE because it is more accommodating to changes. The framework selected from AGILE is Extreme Programming(XP). We have chosen this framework because we are a small team working on a big project. Extreme programming adapts to change by involving everyone with a stake in the outcome of the decision-making process. Extreme programming is extreme because it transforms development into extremely small but important steps with extensive feedback all along the way.

3.4. System Architecture:

The figure bellow presents the interconnection of devices that allow the Smart liquefied petroleum gas stove to operate.

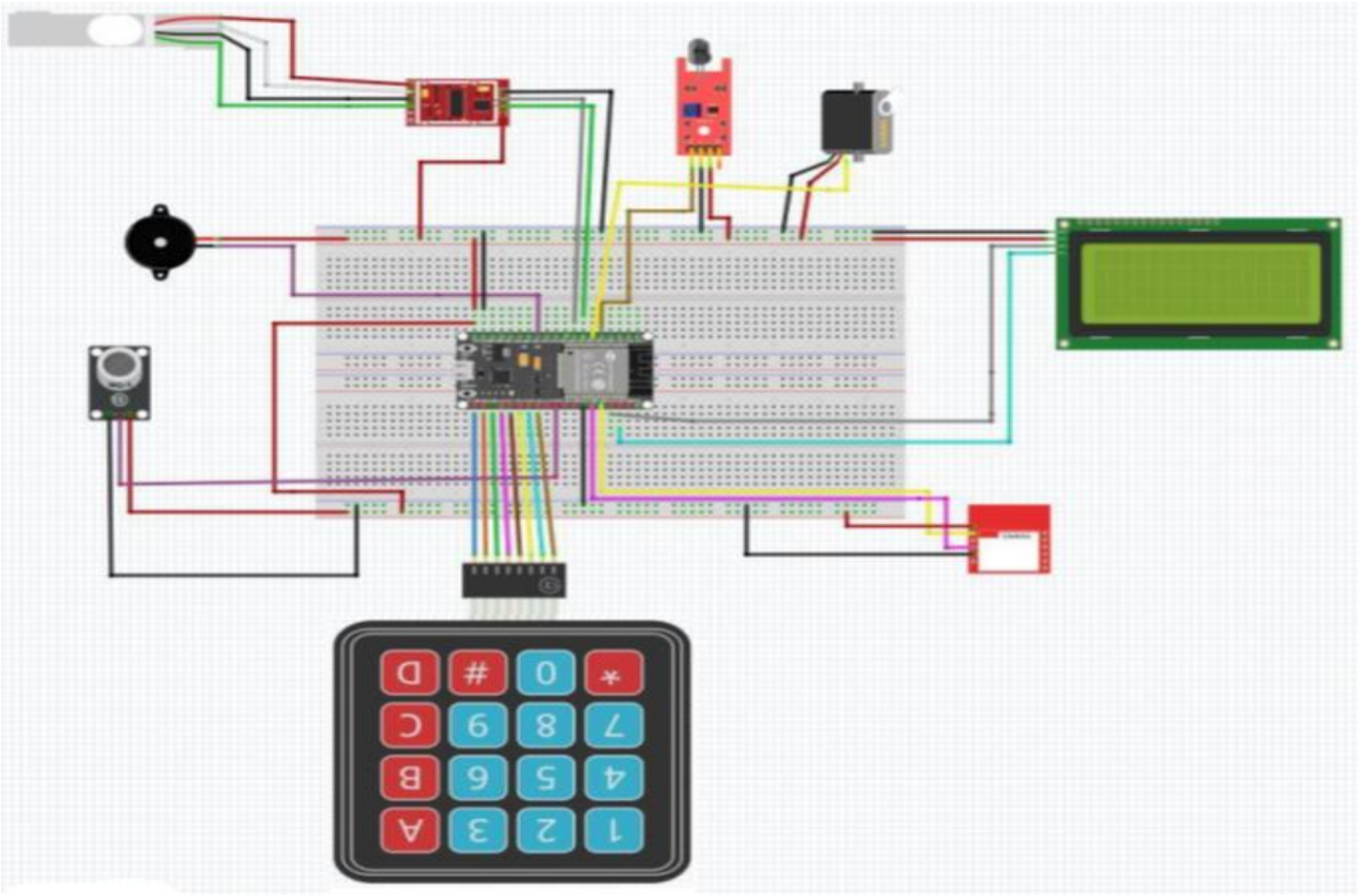

Figure 2. System architecture

3.5 Flowchart diagram

This figure represents the logical functionalities of the system from the starting point, how the system achieves the goal and operate and how it ends its activity of controlling and monitoring the LPG.

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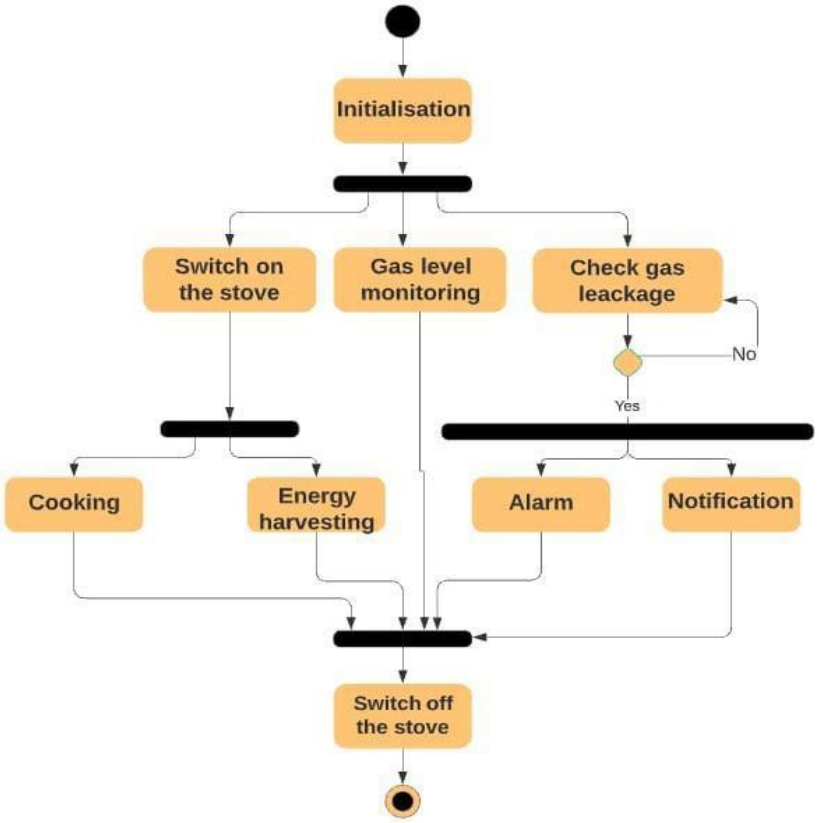

Figure 3. Flowchart diagram

4. RESULTS

4.1. Hardware part

The Hardware subsystem development stage combines all needed embedded systems together with an appropriate condition to come up with the full functioning prototype as one of the most important tasks of this engineering process. The user starts the system by pressing the ON/OFF switch. Then the LCD displays information about the stove such as the weight of gas remaining into the cylinder, and the status of the stove.

The user can then press a button on the keypad to switch on the stove. The gas is then released according to the signal sent to the solenoid valve. The servo then rotates the knob to allow the gas to reach the cooking side. That time the ignition system generates the sparks for some milliseconds to burn the gas. As soon as the flame sensor detects fire and the solenoid lock pulls back the ignition so that it cannot be burnt.

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Figure 4. Hardware Subsystem

Similarly, the user can get alert with the buzzer and display message to the stove display at the same time it can send the notification Message to the user's Telephone When there is a leakage detected by the system.

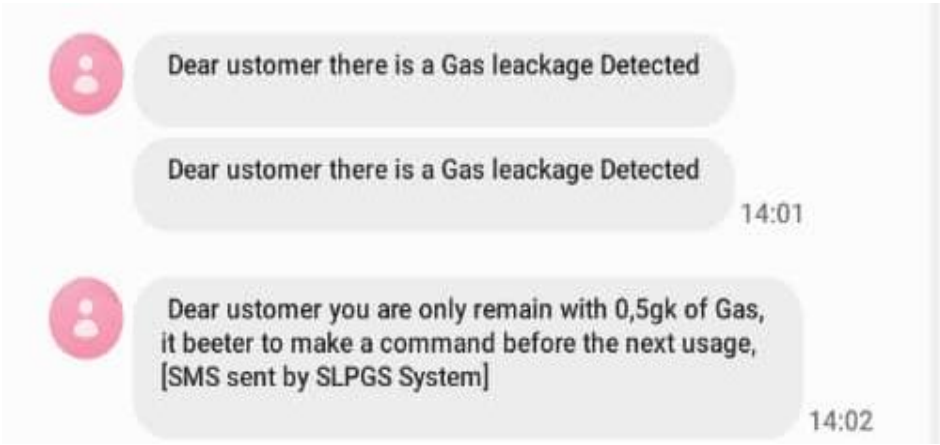

Figure 5.Gas leakage Alert SMS

3.5. Mobile Application

Similarly, the user can access the stove through the mobile phone via the Blynk app. He/she gets notified as soon as there is gas leakage. Also, He/she can monitor the level of the gas and the status of the stove (if it's ON or OFF). We can also command the stove to turn the fire ON and OFF using that mobile. Note that mobile app control and monitoring are only accessible when the system has an internet connection.

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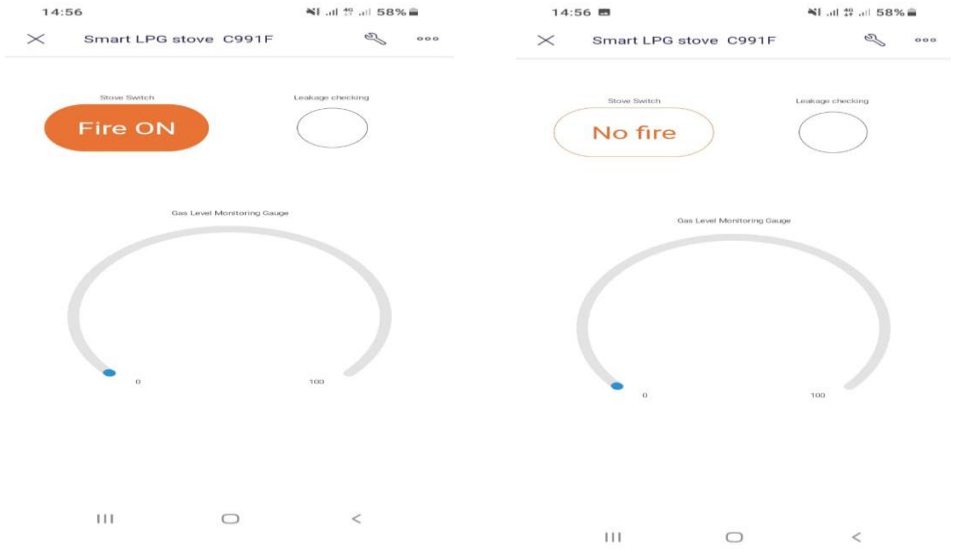

(A) Stove ON

(B) Stove OFF

Figure 6. Mobile app

5. CONCLUSION AND RECOMMENDATION

For clean cooking energy, LPG is among the best option. Integrating stoves that are using LPG with IoT technology shall make their use more comfortable. The user will not worry anymore about seeing the gas in the middle of the cooking process or forgetting the fire on and having to be around to turn it off. The proposed solution will lead to a considerable increase in the number of people using this gas for cooking. This will thus allow people to reduce air pollution and increase environmental protection against deforestation. During the design and implementation of the system we have faced many challenges namely not getting the equipment nearby, when we order they delay. Another challenge is that there was not enough space in the lab, thus the only choice was to work in the hostel, and sometimes the power goes off and obliged us to stop working for a while. But we could have got a place in the lab, there even if the electricity goes off, the generator is supplying. Despite all that the system has been implemented successfully.

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