DOMESTIC WATER SUPPLY MONITORING AND THEFT IDENTIFICATION SYSTEM

Abstract

A vital component of life is water. One of the most significant problems affecting the globe today is the inefficient way of consuming water. Water usage needs to be regulated in order to guarantee a reliable supply for domestic and other uses. This work presents the design of a low-cost system for the Internet of Things (IoT) real-time water supply monitoring. A system with several sensors is utilized to measure the water's flow rate. These sensors are controlled by a controller that has the ability to process the gathered data from the sensors. For the purpose of supplying water to the users, the system is additionally connected with an electrically controlled solenoid valve. The water flow rate is regularly monitored using the flow sensor and updated to the cloud platform which is implemented using Thingspeak. This platform is also monitored by government officials who perform data analysis and storage. When the water flow rate exceeds a pre-determined threshold, the solenoid valve that controls the flow of water is shut down and a water theft alert message will be sent to the customer to his registered mobile number using the telegram application. The excess flow rate is observed by government officials who can take up necessary legal action.

Keywords: ESP32, Solenoidal Valve, Flow Sensor, Thing speak, Telegram.

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I. INTRODUCTION

In urban areas experiencing rapid economic growth, the demand for water by residents is on the rise. Water stands as a vital resource for all living organisms on our planet. However, due to the uneven distribution of this resource, certain individuals may find themselves lacking access to an adequate water supply. Various factors contribute to wastage of water, encompassing the use of potable water for gardening purposes and the inadequate detection of water leaks. To address these challenges, a proposed solution involves integrating a flow meter, solenoid valve, and relay circuit with an ESP32 controller. This amalgamation aims to establish an efficient water supply system. The relay circuit functions as a safeguard, cutting off the water supply to the valve when the flow surpasses a certain threshold. This system empowers the adjustment of water allocation to specific habitats. Moreover, a solenoid valve equipped with an electric motor is employed to efficiently distribute water to consumers. The valve operates by opening or closing when the flow rate crosses a predetermined threshold, thereby controlling the water supply. Furthermore, the regulation of water flow over specific time intervals is facilitated by the integration of solenoid valves with the relay circuit. This orchestrated approach ensures that water resources are managed effectively and judiciously.

II. MOTIVATION

A revolutionary step towards a water-secure future is the Water Theft Identification System. This method attempts to efficiently prevent water theft, protecting our most valuable resource for both the current and future generations. It does by utilizing technology, involving the community, and cooperative efforts. The Water Theft Identification System will support an approach towards sustainable water management practices by developing a feeling of personal accountability and raising awareness while making sure that every drop matters in our joint path toward a more water-secure future.

III. LITERATURE SURVEY

B. Sasikumar et al emphasize the significant water consumption within apartment complexes. The researchers introduced a system for monitoring household water supply and managing billing, employing an Arduino Mega 2560 microcontroller and a dual relay to automate switching functions. To regulate water usage across different floors of the apartment building, water level sensors and valves were incorporated. Detecting the volume of water utilized, water flow sensors were utilized to generate accurate billing statements. This work underscores the authors' efforts to address water usage efficiency and billing accuracy within residential complexes. [1]

J.P. Shri Tharanyaa, A. Jagadesan, et al introduced an embedded remote water monitoring and anti-theft system that focused on tracking flow rates at the consumer's end. The system utilized a microcontroller in conjunction with a flow sensor to measure and transmit flow rate data wirelessly to a remote monitoring station. Additionally, an electrically controlled solenoid valve was integrated to facilitate water distribution to users. This valve was programmed to activate or deactivate, effectively ceasing water supply upon surpassing a predetermined flow rate threshold. For water replenishment, a DC pump was employed to automatically refill the tank from the primary water source. This innovative work demonstrates their endeavor to enhance water management, deter theft, and ensure efficient water supply. [2]

Anil Gantala, Paparao Nalajala, et al shed light on the issue of water theft and the inconsistent nature of water distribution. They tackled this challenge through the implementation of automation and monitoring frameworks. These architectures encompassed a supervisory and control system that facilitated real-time setup. The system utilized programmable logic controllers endowed with fundamental functional abilities, communication systems, and interfaces – whether standardized or tailored – equipped with proximity sensors, electrical drive components, measuring instruments, and more. Their efforts materialized in the creation of a water monitoring and theft prevention system, hinging on PLC (Programmable Logic Controller) and SCADA (Supervisory Control and Data Acquisition) technologies. [3]

Thinagaran Perumal and collaborators introduced an Internet of Things (IoT)-based water monitoring system designed to provide real-time measurement of water levels. The model's fundamental premise lies in the significance of water level as a crucial parameter in predicting and managing flood occurrences, particularly in disaster-prone regions. [4]

Perumal T. and colleagues highlighted the substantial proliferation of Internet of Things applications, particularly in smart homes. This surge in IoT applications has led to a diverse array of requirements for interoperability that must be met. The researchers addressed this by proposing an architecture founded on the Event-Condition-Action (ECA) method, which aims to intelligently manage the heterogeneity of IoT devices in smart homes, thus addressing decision-making deficiencies in existing physical platforms. [5]

N Vijaykumar and team emphasized the imperative of real-time monitoring of drinking water quality. To address this, they developed an affordable system for real-time water quality monitoring within the context of the Internet of Things. This system harnessed multiple sensors to measure both physical and chemical parameters of the water, underscoring the significance of maintaining water quality standards. [6]

IV. IV. COMPONENTS

1. **ESP32 Controller:** Illustrated in Figure 1 is an ESP32 controller, a collection of open-source, cost-effective, and energy-efficient systems encompassing a microcontroller chip with built-in Wi-Fi and dual-mode Bluetooth capabilities.

Figure 1: ESP32 micro-controller

The ESP32 boasts 34 GPIO pins, each of which can function as a versatile input or output, or can be linked to an internal peripheral signal.

2. **Solenoid Valve:** Figure 2 shows a solenoid valve which is the same as the manual valve. In a manual valve. there is a lever that helps the user to on and off the supply, the interfacing of the Arduino interface to the solenoid lock is discussed later.

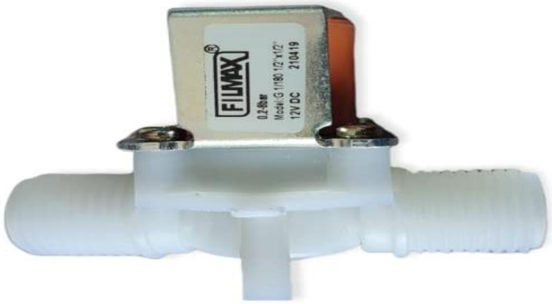

Figure 2: Solenoid valve

3. **Flow Sensor:** In Figure 3, we observe a flow sensor—an electronic instrument responsible for quantifying or managing the flow velocity of liquids and gases within conduits and tubing. These flow sensors are commonly affixed to gauges to present their measurements, although they possess the capability to establish connections with computers and digital interfaces for data integration as well.

Figure 3: Flow Sensor

4. **Relay:** Depicted in Figure 4 is a relay module, an electronically actuated switch. This module comprises a collection of input terminals designated for single or multiple control signals, alongside a group of operational contact terminals. The controller can encompass a variable count of contacts, adopting diverse contact configurations such as make contacts, break contacts, or combinations of the two.

Figure 4: Relay Module

5. LCD:

Figure 5: LCD Display

Figure 5 shows a 4-bit data interface for compatibility with ARM boards

- LCD_E, LCD_RS, LCD_RW
- 2-line x 16-character Display
- Each character location consists of a 5-dot x 8-bit display.

6. I2C Serial Interface LCD Adapter Module: Illustrated in Figure 6 is a typical 16x2 LCD display, which even when functioning in 4-bit mode, requires approximately 8 GPIO pins from the microcontroller to showcase information. In scenarios where GPIO pins are limited, this allocation can be quite substantial. This underscores the necessity for a serial-to-parallel data adapter, enabling a reduction in the quantity of pins essential for steering the LCD display modules.

Figure 6: I2C Serial Interface LCD Adapter Module

7. **Li-ion Rechargeable Battery:** Depicted in Figure 7 is an 18650 battery, a rechargeable Li-ion battery featuring a Battery Capacity of 1200 mAh. Differing from the standard AA or AAA battery, this variant proves highly valuable in scenarios necessitating sustained high current or abrupt surges of high current, as witnessed in devices such as cameras, DVD players, iPods, and similar applications.

Figure 7: Li-ion Rechargeable Battery

V. IMPLEMENTATION

1. **Block Diagram:** Figure 8 shows the block diagram containing a microcontroller (ESP32), flow sensor, solenoidal valve, relay, and LCD. The ESP32 is the main processor of the system which controls and processes the data generated by the sensors. The flow sensor helps to measure the flow rate when the water flows into it. The solenoid valve is an automatic on-and-off valve to control water flow automatically. If there is high flow than mentioned, by the customer side then the message is then passed to the solenoidal valve through the relay to stop the water flow, and the flow is disconnected.

   The message is always displayed on the LCD in the model. The message with the total water flow rate and the disconnected message is sent to telegram and Thingspeak for storage. This process continues till the operator turns the system off. The data is stored in the cloud (Thing speak) and the result is shown in the graph format. The data from the cloud can be exported into CSV files and other forms.

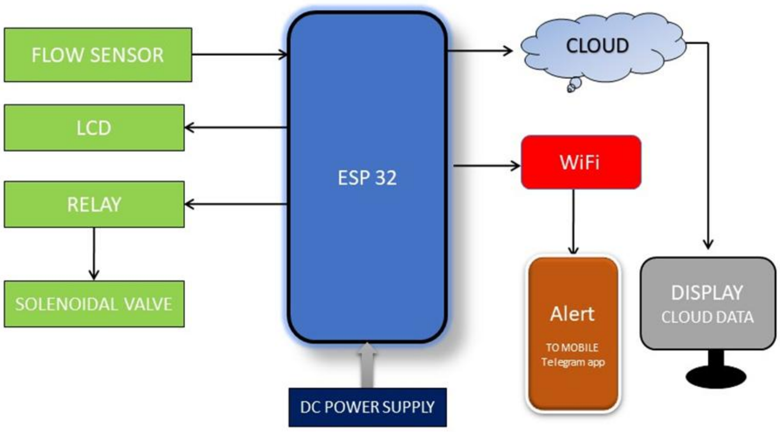

Figure 8: Block Diagram of Proposed System

2. **Flow Chart:** Figure 9 shows the flowchart of the proposed system. The system is initiated with a regulated supply of water. The flow of water is then monitored and assigned a threshold based on the survey and data analyzed. It is manually provided by the authoritarians and the supply of water is initialized. The supply rate and quantity of water consumption are displayed on the LCD.

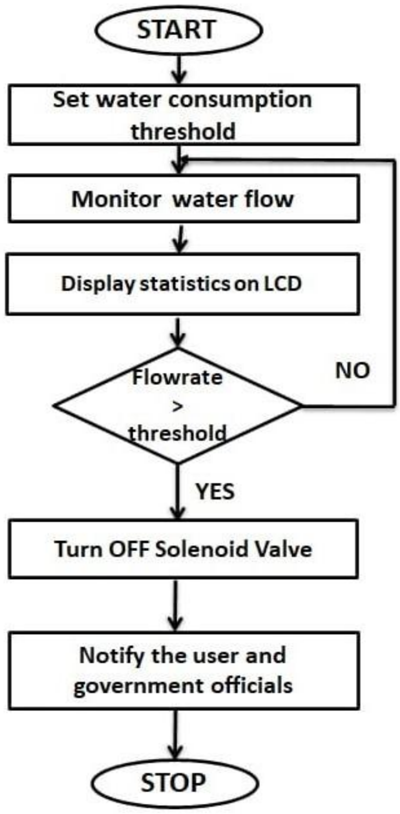

Figure 9: Flow Chart of the Proposed System

The water is observed to flow at a normal flow rate. Based on the condition that if it exceeds the flow rate, the solenoid valve is set to shut down automatically. It is automatically invoked to generate a notification to the customers via the telegram application bot. It automates a message to the consumers with the registered ID. The notification provides the consumers with the disabled water supply due to the proposed system experiencing water theft.

This data is further updated in the cloud platform Thingspeak, when the disconnection of the water supply and the system identifying theft on the consumer's end is observed.

3. **Circuit Diagram:** Figure 10 shows the circuit diagram of the proposed system. It illustrates the steps of connection used to interconnect the multiple components used to perform the water theft identification.

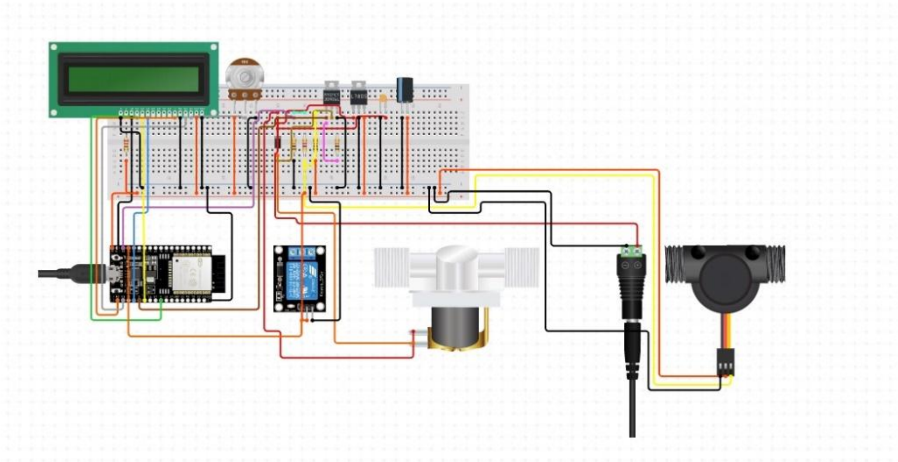

Figure 10: Circuit Diagram of Proposed System

The connections starts with the battery of 8V connected to the switch on the positive terminal and the Relay connected at the negative end of the terminal. The relay. The flow sensor is connected to the 3V pin on the circuit(red), a wire is connected to the ground connection (Black), and another pin is connected to G34.

The LCD is capable of displaying the output message on the screen that is connected to the VCC of 5V, a ground pin of G22, and another pin-to-pin number G21. The relay pin of 12V is connected to the supply of 5V and a ground pin is to the grounding. The relay input is connected to the G5 pin of ESP32. A buzzer is used to notify the surrounding in case of theft identification detected by the system. The buzzer is connected to the system by connecting the positive terminal to the G12 pin on the ESP32 kit and the negative terminal of the system to the Ground pin of the system.

4. **Arduino IDE Software:** Arduino IDE, an official software developed by Arduino.cc, serves as a primary tool for composing, compiling, and uploading code across a wide spectrum of Arduino modules and boards. This open-source software is readily accessible for download and installation. Designed by Arduino.cc, the IDE streamlines the process of code creation, compilation, and uploading for various Arduino Modules. Its user-friendly design ensures that individuals without advanced technical knowledge can comfortably initiate their learning journey. Armed with availability for major operating systems such as MAC, Windows, and Linux, the Arduino IDE operates on the Java Platform. This platform is equipped with integrated functions and commands pivotal for code debugging, editing, and compilation. Supporting a range of Arduino modules including Arduino Uno, Arduino Mega, Arduino Leonardo, and Arduino Micro, the IDE simplifies the task of code development across diverse hardware options.

VI. RESULTS & DISCUSSION

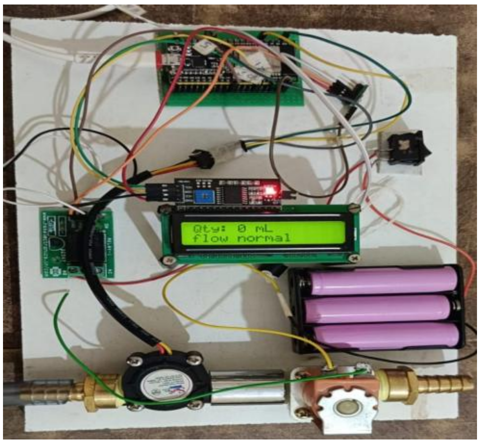

Figure 11: Model Image with Normal Flow

Figure 11 shows the proposed system that is used to monitor the flow rate in the system. The above picture depicts the normal flow of water and its readings on the LCD.

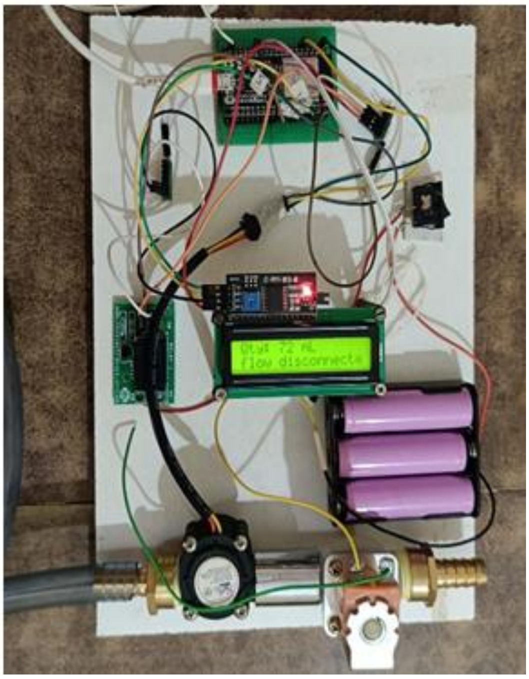

Figure 12: Model Image with Flow Disconnected

Figure 12 shows the model of the proposed system that depicts the disconnection of the water flow in the system. The message is displayed on the LCD upon reaching the threshold.

1. **Telegram:** Figure 13 shows the telegram application interface that provides the notification of the water supply system being shutdown when the flowrate of water exceeds the threshold

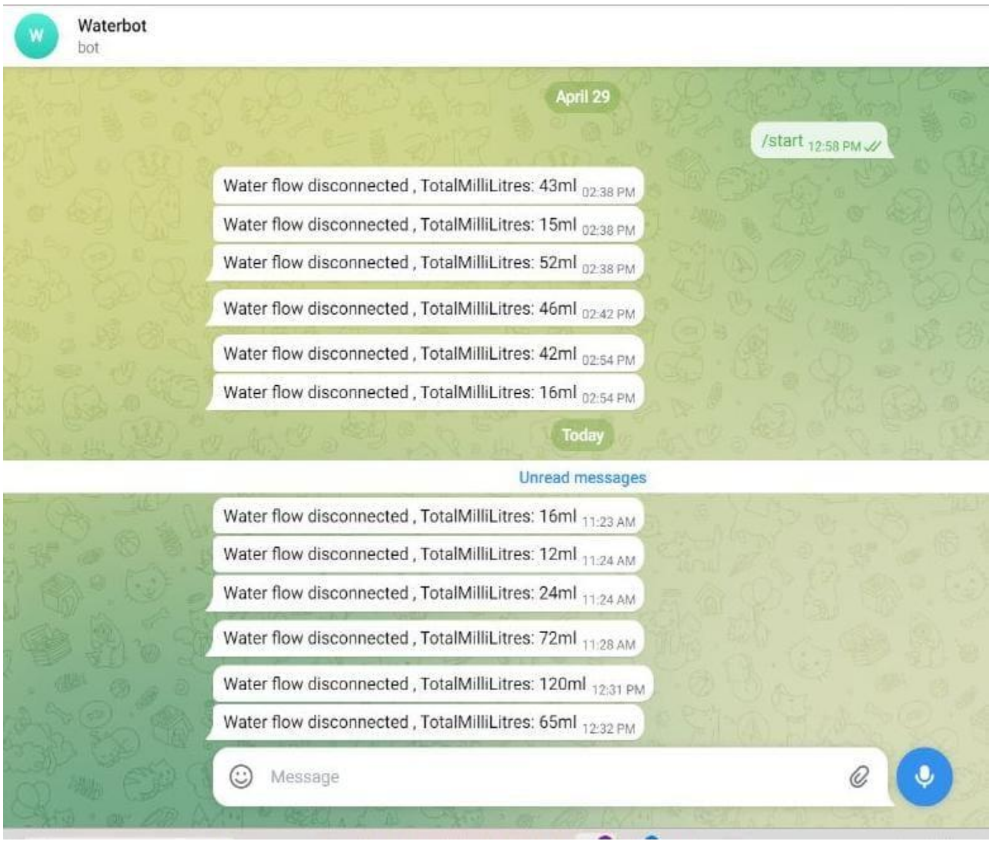

Figure 13: Flow rate and disconnected notification in Telegram

2. **Serial Monitor:**

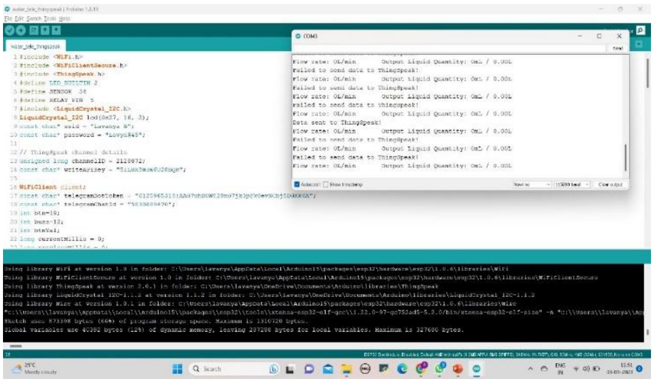

Figure 14: Serial monitor showing output readings

Figure 14 shows the serial monitor that is used to fetch the live data of the output used in the Arduino IDE capable of feeding the data into the controller and getting the updates of loading and running the relevant code into the system.

3. **ThingSpeak:** ThingSpeak serves as an Internet of Things (IoT) analytics platform service, offering the capability to gather, depict, and scrutinize real-time data streams within the cloud. This platform facilitates the accumulation of resultant data, which is subsequently presented in graphical format for easy interpretation.

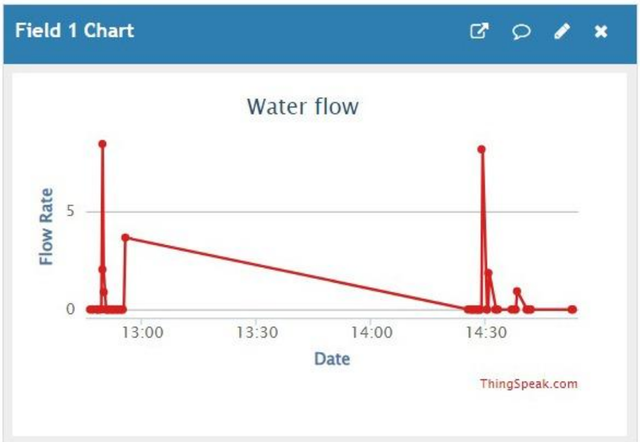

Figure 15: Flow Rate stored in the cloud.

Figure 15 depicts the graphical representation of a data analysis on the cloud platform Thingspeak in the system. It provides the graph of Flow rate v/s date chart and consumption data.

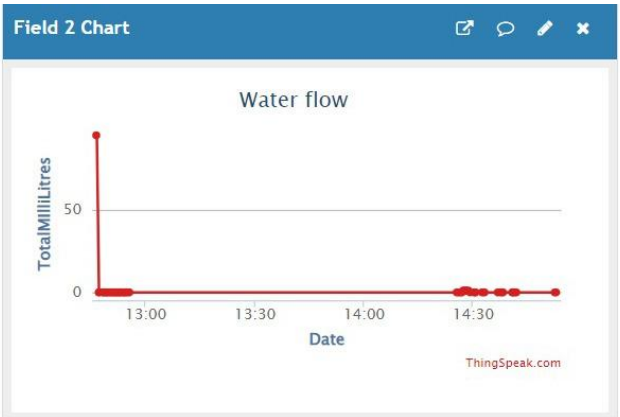

Figure 16: Total milliliters v/s date graph in Cloud

Figure 16 shows the graphical representation of the quantity v/s date graph that presents the total water quantity considered to be used by the consumers. The data is updated to the Thingspeak cloud platform that is observed by the authoritarians under the access of these data analysis.

VII. CONCLUSION & FUTURE SCOPE

This study introduces an IoT-based prototype water monitoring system. The core of this system relies on the utilization of flow sensors. The data collected from these sensors is harnessed for in-depth analysis, aiming to provide enhanced solutions to water-related challenges. By employing a Wi-Fi module ESP32, the amassed data is transmitted to a cloud server. This innovative prototype proves particularly beneficial in urban regions and locales grappling with water scarcity concerns. The incorporation of this prototype in real-world scenarios offers governmental bodies an opportunity to ensure equitable water distribution among citizens, minimizing conflicts and disparities. This initiative holds the potential to foster unity, tranquility, and the prudent conservation of water resources, benefitting both the current generation and those yet to come. Furthermore, there is room for further advancement in this work. The system's capabilities could be extended to encompass the identification of theft in other liquid supplies such as liquid petroleum gas and fuels. This potential expansion could be of immense value to governmental bodies for efficient management and regulation.

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