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Electricity Misuse With Pzem Anomaly Detection and Notification

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ABSTRACT

The purpose of this study was to create an Electricity Misuse with PZEM Anomaly Detection and Notification System to address the challenges in apartment electricity monitoring, including misuse detection, excessive consumption and failure to track the actual consumption, and eventually enhance efficiency of the landlords and tenants. The scope, development and implementation of a system that can monitor per-room electricity usage, abnormal usage and provide timely alerts with integrated hardware and software, such as sensors, microcontrollers, communication modules and a web-based dashboard were covered. The methods involved identifying existing problem, designing of system architecture, and assembly of the components like the PZEM-004T, Arduino R4, and ESP32 and development of the software to collect data, process it and monitor it remotely and then testing it in a real-world environment at the Mar-Lee Apartment in General Santos City with the involvement of the landlady and tenants. The results demonstrated that the system was able to monitor electricity consumption, identify anomalies correctly and issue timely alerts, garnering good reviews in terms of functionality, usability and reliability, acceptability as well as physical and hardware aspect. In conclusion, the system is a convenient, efficient, and cost-effective solution to the current problem of better electricity management, minimize the misuse, and more responsible use of the energy among tenants.

INTRODUCTION

Electricity plays a crucial role in the modern society, especially in apartments where several tenants share a single power supply. Although it is essential, electricity misuse is a significant problem that can be unnoticed frequently, resulting in higher utility bills, unequal distribution of bill payments, and possible safety concerns like overloading of circuits and fire problems. Traditional check meters are still in use in most apartment environments, particularly in the Philippines, only recording the aggregate consumption but not giving a fine look into individual consumption or abnormal consumption habits. This is a disadvantage that renders monitoring and controlling the use of electricity by tenants hard to do by property owners. The increasing issue of the non-technical losses, such as electricity misuse, unlawful connections, and abnormal consumption, persists to impact consumers and utility suppliers globally (Alcaraz, 2022; International Energy Agency, 2021). Research has demonstrated that such losses contribute to high operational costs and inefficiencies in power distribution systems (Ahmed *et al.*, 2022; Chen *et al.*, 2026). The latest development of energy monitoring technologies puts an accent on the application of real-time data capture, anomaly detection, and automated notification systems to overcome these issues (Zulu and Dzobo, 2023; Tsao *et al.*,, 2024). Nonetheless, the available solutions tend to be complicated, costly or tailored towards large scale smart grids applications thus are not realistic to small residential set ups like apartments and boarding houses. To address these issues, this study proposes the creation of an Electricity Misuse with PZEM Anomaly Detection and Notification System. The system will track electricity consumption on a room-by-room basis, identify the abnormal use of the power using anomaly detection methods, and provide real-time alerts to the landlady and tenants. The system will facilitate equitable electricity consumption, increase safety, and boost the efficiency of energy management by incorporating PZEM sensors, microcontrollers and web-based monitoring platform. The primary objectives of this study are to design and develop a system that can accurately monitor electricity usage, detect misuse and provide timely notifications. Specifically, it aims to address the limitation of conventional monitoring techniques with a low-cost, reliable and accessible solution that targets small residential settings.

LITERATURE REVIEW

Related Literature

Alcaraz (2022) measured NTL, recording pilferage activity (jumpering, direct tapping, meter tampering) as causing 7-12% of losses in 2019-2021, and an associated cost increase in direct consumer costs of 0.3050 per kWh. Francisco (2022) studied the interruptions in electricity supply in Philippine cooperatives, with 5.7 interruptions with a total of 8.8 hours per year in 2021. Nebrida *et al.*, (2023) built a smart meter based on PZEM-016, NodeMCU ESP8266, Arduino Uno, and the Blynk IoT platform, with high agreement of prototype and utility meter readings. In Leynes (2024), a distributed load monitoring system was deployed based on split-core current sensors and ESP32 with visualization in the cloud through Google Sheets and Looker Studio. Zulu and Dzobo (2023) suggested a real-time dual-metering

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electricity theft detector system that had a detection efficiency of over 95% with Arduino ATMega328P, GSM modules, and cloud storage. Tsao *et al.*, (2024) showed that machine learning analysis of four-hour interval showed an 11.8 percent improvement in the accuracy of anomalies detection. In Collier and Guha (2025), the authors presented a low-cost LSTM watch-level watchdog system that consumes 64% the computational energy by activating on events. Stevenson *et al.*, (2025) highlighted the need to complement the technical monitoring with policy interventions and social awareness campaigns in developing countries.

Related Studies

The system created by Alibin *et al.*, (2021) is based on IoT and consists of current sensors, Arduino microcontrollers, and Wi-Fi modules that have demonstrated the ability to identify abnormal consumption patterns in real-time by using a set of predetermined thresholds. By using two current sensors and Arduino Mega, Mababa (2023) created a real-time tracking system with GSM-based notifications and an Android app, which had a high success rate in detecting unauthorized electricity usage. Nebrida *et al.*, (2023) used PZEM-016, NodeMCU ESP8266, Arduino Uno, and the Blynk IoT platform to implement a smart energy meter, showing a high correlation between prototype and utility meter measurements. Leynes (2024) implemented a distributed load monitoring system based on split-core current sensor and ESP32 to detect transformer overloading states up to 149.55% with visualization tools of cloud computing systems such as Google sheets and Looker Studio. Haqu *et al.*, (2023) used a deep convolutional neural network (CNN) on massive datasets of smart meters that enhances the accuracy of anomaly detection and false positives by introducing sophisticated preprocessing methods. Ahmad *et al.*, (2025) applied anomaly detection algorithms to detect abnormalities in electricity market supply and demand, showing the usefulness of such methods to detect suspicious trends. Collier and Guha (2025) developed a low-cost LSTM-based watchdog system that used less than 64% of the computational-energy consumption during irregular events but still, the system still exhibited high-quality performance in determining anomalies.

MATERIALS AND METHODS

Research Design

The research design used in this study was descriptive and a questionnaire served as the major data collection instrument. The survey was given to the concerned respondents, which comprised the boarding house landlord, and tenants. The questionnaire contained the items to assess the operational features of Electricity Misuse with PZEM Anomaly Detection and Notification, in particular, its functionality, effectiveness, accuracy, acceptability and hardware and physical aspect.

Hardware Components

The hardware components of the Electricity Misuse with PZEM Anomaly Detection and Notification System are designed to work together to allow accurate monitoring, processing, and communication of electrical data accurately and safety. The system uses the ESP32 for use as a wireless repeater via WiFi and Bluetooth to extend the range of communication so that data from the sensing nodes can be transmitted to the monitoring station even if they are located a long distance away. The Arduino R4 functions as the primary edge device that collects real-time electrical measurements via the PZEM-004T AC energy meter, which accurately measures voltage, current, power, energy, and frequency with electrical isolation for safe operation. The processed electrical measurements will be displayed locally via a 20x4 LCD, allowing users to monitor in real-time how much electricity is being consumed. Power for the system is provided by the HLK-5M05 module, which converts AC to a stable 5V DC output and protects the system from overload and electrical noise. A 5V Opto-isolated relay module is used to provide safe switching of high-voltage loads, while LED indicators provide immediate visual notifications of abnormal usage or system faults. All components are connected to a PCB to ensure stable wiring, correct power supply, and electrical safety, and the entire system is enclosed in a protective enclosure that protects against dust and moisture as well as accidental contact to ensure durability and safe deployment in real-world environments.

Software Architectures

The software architecture links sensor nodes, the main gateway and the monitoring interface and the process of data collection and communication are uninterrupted. It is a combination of microcontroller program, data processing, database management and web development to accumulate, store, and present data in real time. The simple web interface allows users to monitor the status of the system, data trends, and alerts. The structure also provides the system with reliability in transferring data, accuracy, and scalable and efficient management of the system. It can be easily extended to both additional sensors or data of new types without significant modifications. This versatility makes it applicable to a great variety of applications including environmental monitoring, industrial automation.

Technical Feasibility

The proposed system is novel and technically feasible based on a number of factors. The devices and materials involved in the design of the Electricity Misuse with PZEM Anomaly Detection and Notification System, the ESP32, Arduino R4, PZEM sensor, and relay switches, can be purchased locally and are readily obtainable. Moreover, the software and hardware components are simple to service and fix since the proponents are able to perform the real monitoring and troubleshooting either directly at the boarding house or remotely with their respective

computers. SMS is also used in the system in order to provide notifications, which enhances the communication between the proponents, the landlord, and the tenants because it gives an alert that there is misuse of electricity or abnormal consumption habits. This information delivery system is effective and responsive because it is more efficient and convenient since the information is delivered promptly using the SMS-based communication system.

Economic Feasibility

The respondents also found the proposed system to be economically viable. The hardware components, including the sensors, ESP32, Arduino R4 were inexpensive and could be bought at reasonable prices by the local suppliers. Because the software platforms and the programming tools employed in the research are an open-source and can be freely downloaded, no extra costs were incurred in terms of licensing. In addition, the system can be used to minimize misuse of electricity and billing disputes, which eventually may save a lot of money to both the boarding house owner and the tenants. Maintenance is also cheap and needs only the occasional checks of the components or replacements which are not costly. In general, the savings and benefits in the long-term of the implementation of Electricity Misuse with PZEM Anomaly Detection and Notification System, exceed its upfront development and installation expenses, making it a viable investment.

Cost Analysis

The total cost of implementing the system on Mar-Lee Apartment is ₱46,000; however, its expected break-even point is about 14 months after installation. In the first two years after deployment, cumulative savings are estimated at approximately ₱132,290 due to reduced electricity, improved billing accuracy, and preventing overloading events. As a result of the above metrics, the system is a financially viable investment for any property owner. In summary, the short payback period together with the significant long-term ongoing savings reflect that the system provides significant economic value. Thus, this system can support cost efficiency and improved use of resources in other residential buildings as well.

Data Gathering Procedures

The researchers began by drafting a formal letter to the instructor explaining why the study was important, what procedures it would involve and why the study was important. Upon the approval, the researchers developed and piloted a structured questionnaire with the help of which the perceptions of the respondents concerning the system were captured. The respondents including the landlord and the tenants were chosen carefully based on the engagement they have concerning the use and management of electricity. This rendered the data valid and applicable towards the study objectives. All the respondents provided an informed consent, and their involvement in the survey was voluntary. They were assured of confidentiality in order to make them open up and to be truthful. The questionnaire was administered in print, and it contained closed-ended questions to enable the respondents to give clear and consistent responses. Each participant was allowed enough time so that no questions were not answered in the best way possible. Following the retrieval of the questionnaires which had been filled in, the responses were tabulated and systematically organized and analyzed to establish trends, correlations, and important responses. Besides the survey, the prototype system was also subjected to real-life boarding house situations, where respondents could also experience and test its real performance, especially on its functionality, effectiveness, and reliability.

Data Gathering Instruments

To conduct the study in a proper way, the survey questionnaire became the primary source of collecting the required information. It was chosen due to its cost efficiency, ease of use, and capability of acquiring structured information of numerous respondents in a limited duration. Electricity Misuse with PZEM Anomaly Detection and Notification evaluation form was specially built to assess different dimensions of the system performance and usability. The questionnaire was created on the 5-point Likert scale according to which interviewees had to evaluate their degree of agreement or satisfaction with certain aspects of the system. The assessment was done on three main dimensions:

Functionality - how the system carries out its desired functions like the detection of electricity misuse and high-power appliances.

Efficiency - is the anomaly identified correctly, are the notifications understandable and is the web-based dashboard responsive.

Accuracy - system operation stability, stability of the esp32 communication and stability of the cutoff system based on relay.

Acceptability - the level of whether the system satisfies the needs and expectations of the users including ease of use, convenience and general satisfaction with the monitoring and control capabilities.

Hardware/Physical Aspect- how the physical components such as sensors, microcontrollers, relays, and the central gateway are designed, how long they last as well as how reliable they are against normal operating conditions.

All of the filled in questionnaires were tabulated and collected. These responses were subsequently subjected to quantitative analysis so as to find out the overall beliefs and experiences that the respondents had thereby providing an assessment of the performance of Electricity Misuse with PZEM Anomaly Detection and Notification system overall.

Statistical Tools and Treatment of Data

Electricity Misuse with PZEM Anomaly Detection and Notification was to evaluate its functionality,

effectiveness, efficiency, acceptability and physical aspect. The responses were collected and analyzed/interpreted using descriptive statistics where a 5-point Likert Rating Scale was adopted as the key tool in summarizing the data. Given that the study involved Likert-scale ratings.

RESULTS AND DISCUSSION

Implementation Results

The proposed system was also tested to check the performance and usability of the system before the final implementation in Marlee Apartment, Bayabas Street, Barangay North, General Santos City. Throughout the implementation, the residents were instructed on how the system operates in both software and hardware to properly interpret the features of the software and combine it along with the functionality of the hardware. After the actual testing of the proposed system, the proponents collected the forms filled up by the respondents for survey purposes. The questionnaire was divided into five groups: Functionality, Accuracy, Effectiveness, Usability, and Hardware. The survey questionnaire was distributed to the residents of Marlee Apartment, which the study aimed to gather information about the respondents' current situation, needs, and opinions related to the proposed project, particularly the residents located at Bayabas Street, Barangay North, General Santos City.

Results of Evaluation

Table 1: Landlady Functionality Results

QUESTION	Mean	Description
1.The system can effectively detect electricity misuse in the boarding house.	4	Agree
2.The system identifies high-power appliances accurately when they are in use.	5	Strongly Agree
3.The web-based dashboard clearly displays electricity usage information.	4	Agree
4.The relay mechanism functions properly to cut off power during misuse scenarios.	4	Agree
5.The system performs its intended purpose as designed.	4	Agree
Total Mean:	4.2	Agree

Respondents were asked to rate the performance of the system on five aspects, and its performance can be seen as good in the results. The average of most indicators reached 4, which means 'Agree', demonstrating the system was 70 acceptable for users to know on how to detect electricity abuse in the boarding house, to get consumption information through a web-based dashboard, and to activate the relay mechanism to disconnect the power source in the case of an abusive situation. Meanwhile, a perfect mean score of 5 was obtained for the accurate identification of high-power appliances during active usage, which corresponded to "Strongly Agree" and is the highest possible score, indicating that this was a highly impressive feature among the respondents. In general, the system usability was highly rated, with an overall mean score of 4.2 in the between-subject group, which is interpreted as "Agree". This shows that the users, in general, believe that the system does what it is supposed to do. The unanimous agreement on all five traits among the participants indicates that the system is applicably solid in addition to being superior in technical manner and reliability as the system from the users' point of view. These results further enhance the viability of the proposed system as a promising candidate for a solution to monitor and control electricity consumption in a boarding house, particularly with its high-power appliance detection capability to be a key element to be highlighted in future work.

The system was evaluated based on five criteria, and

Table 2: Landlady Effectiveness Results

QUESTION	Mean	Description
1.The system provides timely notifications whenever misuse is detected.	4	Agree
2.The anomaly detection feature is effective in distinguishing normal and abnormal usage.	3	Neutral
3.The web-based dashboard is effective in communicating alerts to both landlord and tenants.	4	Agree
4.The system effectively helps reduce electricity misuse in the boarding house.	5	Strongly Agree
5. The system achieves its objectives in monitoring and controlling power usage.	4	Agree
Total Mean:	4	Agree

the answers indicate a rather positive judgment of the respondents. Four of the five indicators were rated as 4 which is considered to respond to Agree meaning that the system was deemed reliable as providing timely notification whenever the misuse shall be identified, effective in delivering notifications to both the landlords and tenants via the web-based dashboard, and effective in accomplishing its purpose of monitoring and controlling power use. The most outstanding outcome was the capacity of the system to assist in minimizing the misuse of electricity in the boarding house and this received a high mean score of 5 or "Strongly Agree," showing that the respondents have a strong belief in the true essence of

the system in dealing with energy misuse at the household level. This implies that the respondents did not disagree with its effectiveness when characterizing the difference between normal and abnormal use but there is still room to improve the effectiveness or the impression a given algorithm will have on users. The total mean score of 4, which can be termed as, Agree, indicates that the system is widely believed to be working well in achieving its intended role. This compromised result shows both the strong points of the system and a definite direction of further improvement, especially of the component of anomaly detection that will increase the level of trust of users.

The system was evaluated on 5 criteria and the results

Table 3: Landlady Accuracy Results

QUESTION	Mean	Description
1.The system provides correct results without errors.	4	Agree
2.The communication module accurately transmits data between devices.	4	Agree
3.The system delivers precise usage data at all times.	4	Agree
4.The system maintains correct functionality during prolonged usage.	4	Agree
5.The Electricity Misuse with PZEM Anomaly Detection and Notification system provides accurate performance and results.	4	Agree
Total Mean:	4	Agree

have provided a very consistent image of a reliable performance. Each indicator had the mean score of 4 and was all within the range of agree, which is indicative of the consistency and reliability of the accuracy of the system in all dimensions of assessment. Respondents confirmed that the system is not erratic in the results given, the Esp32 communication module sends data correctly, and that the use of equipment is accurate and precise data are given at any time. Such consistency in scores indicates that the user had a balanced and technically competent system where no one tested area of accuracy performed poorly or was a weakness. To further support this up-beat evaluation, the respondents also concurred that the system retains proper functionality in the case of extended usage, and that overall Electricity Misuse with PZEM Anomaly Detection and Notification system offers appropriate performance and outputs. All these findings are bundled into a concise and assured the system is right and can be relied upon in its operations by the overall mean score of 4, which was defined as agree. It is also remarkable that the uniformity of all the five criteria is maintained, which means that the system can operate with the same accuracy regardless of the aspect of the hardware communication or the delivery of the data or all-around capabilities to detect electricity misuse in a boarding house setting, which means it is a reliable instrument to monitor electricity misuse in a boarding house setting.

The acceptability of the system in the respondents

Table 4: Landlady Acceptability Results

QUESTION	Mean	Description
1.The system is acceptable for daily use in a boarding house.	4	Agree
2.I am comfortable using the system to monitor electricity usage.	5	Strongly Agree
3.The system meets my expectations as a user.	5	Strongly Agree
4.I would recommend this system to other boarding house owners or tenants.	5	Strongly Agree
5.Overall, I am satisfied with the system's performance.	5	Strongly Agree
Total Mean:	4.8	Strongly Agree

was tested with reference to the five criteria and the results indicate that the system has been received with a resounding positive response. Four indicators out of the five had a mean score of 5 and were rated with a strongly agree option indicating the system has a very high level of user satisfaction and confidence. Respondents were firm that they are comfortable with the system to monitor electricity consumption, that the system fits their expectations as users, they would recommend the same to other boarding owners or tenants, and that, in general, they are pleased with the performance of the system. These almost flawless scores point out to the fact that the system can do what is expected of it and at the same time appeal to its end users personally and more so, practically. The only indicator that scored slightly less was the acceptability of the system to be used daily in boarding house, which had a mean score of 4 or Agree is a strong result but only shows a subtle difference in the perception of the user, but not any major objection. Nevertheless, the overall average rating, which was deemed as the highest of all assessment criteria, is 4.8 which was labeled as agree, which again underlines the fact that the system was well-received by the respondents. This high degree of acceptance means that the system has proven to gain the trust and acceptance of its users to the extent that it is not only a technically effective solution but people have confidence in using and recommending it in a real-life boarding house environment.

The evaluation of the hardware and physical elements of the system was conducted in five items, and its findings reveal a sound and stable user satisfaction. Similar to

Table 5: Landlady Hardware and Physical Results

QUESTION	Mean	Description
1.The hardware components are properly assembled and securely installed.	4	Agree
2.The device casing is durable and appropriate for its environment.	4	Agree
3.The hardware design does not interfere with normal electrical usage.	4	Agree
4.The size and placement of the hardware are convenient.	4	Agree
5.The hardware components function reliably during operation.	4	Agree
Total Mean:	4	Agree

the Accuracy Criteria, each of the indicators in this category was given a consistent mean score of 4, with each one stating that it was an Agree response to a well-built and well-designed physical system. The respondents concurred that all hardware is correctly assembled and properly installed, the casing of the device is of good quality and fit in the environment and the overall hardware design does not intrude with the normal usage of electricity. These reactions indicate that users were convinced about the physical integrity of the system, and they realized that the quality of the buildings is capable of addressing the scope of practical needs of a boarding house environment. The answers of the size, location, and reliability of the hardware were also promising. The respondents concurred that the hardware dimensions and position are convenient and that the parts used work well in the real world when the actual systems are in operation which are very essential factors in the system that is to be installed and used in the normal daily living areas. These findings are then summed up in a unified judgment of the physical design and quality of construction of the system in the total mean score of 4 that would be classified as agree. The ideal consistency in all the five hardware requirements augments the concept that the development team did not only consider the software features of the system and how it will perform, but rather, how long the physical structure will last, be inconspicuous and reliable. The system was evaluated by five criteria to determine its

Table 6: Tenants Effectiveness Result

QUESTION	Mean	Description
1.The system clearly shows how much electricity is being used.	5	Strongly Agree
2.The system helps me understand my electricity usage better.	4.93	Strongly Agree
3. The system makes me aware when my electricity use is high.	5	Strongly Agree
4. The notifications help me take action to manage my electricity use.	4.4	Agree
5. The system is easy to use and understand.	4.2	Agree
Total Mean:	4.70	Strongly Agree

effectiveness as perceived by the tenant, and the findings indicate an extremely high level of satisfaction and interaction. The capacity to be able to clearly demonstrate the amount of electricity that is being consumed, and the capability to create awareness of tenants when they are using a lot of electricity were rated at a 5 and were the two indicators that had the highest rating of 5 out of 5. Also, the role of the system in assisting the tenants to make a more informed decision about the consumption of electricity achieved nearly perfect mean of 4.93, also characterized as strongly agree. These scores show that the tenants were very satisfied with the system since it provided them with a clear and real-time information on electricity, which is visible and easy to understand in their daily life. The other two criteria though slightly lower, still received positive answers to the tenant respondents. The effectiveness of notifications in assisting tenants to act in order to manage their electricity usage had a mean of 4.4, and the ease of use and readability of the system were rated at 4.2, which falls under the category of agree. These findings indicate that although the system is quite efficient in presenting and transmitting electricity information, there is a relatively minor possibility to improve the intuitiveness of its interface and the actionability of its notifications to tenants. However, the overall mean of the scores 4.70, which is defined as Strongly Agree, is the testament to the overall high level of effectiveness of the system on the side of the tenant, which confirms that it does enable the residents to be more mindful and in charge of the electric power they use.

The system was judged on the accuracy as perceived by

Table 7: Tenants Accuracy Result

QUESTION	Mean	Description
1.The wattage shown by the system matches my actual electricity usage.	4.4	Agree
2.The system provides consistent electricity readings.	4.9	Strongly Agree
3. The notifications correctly reflect my electricity usage.	4	Agree
4.The system shows accurate information every time every time I check it.	4.2	Agree

5. I can rely on the system's readings to monitor my electricity use.	4.26	Agree
Total Mean:	4.37	Agree

tenants in five criteria and the results display a steady and positive reporting of trust in the accuracy of data given by the system. The most successful outcome was obtained as a result of the capability of the system to deliver the same electricity reading as the system got a mean score of 4.9 which is termed as strongly agree which almost indicates that tenants found the system highly dependable in providing identical and stable measuring records over a period. Other indicators also fared well with the wattage used by the system indicating the actual electricity usage and the system notifications indicating electricity usage all scoring well in the category of Agree respectively with mean of 4.4 and 4 respectively. These findings draw a portrait of a system that the tenants have the true faith that it will present them with the true and reliable information. The rest of the indicators further supported this good impression as the functionality of the system to display correct information each time it is checked had a mean of 4.2, and the trust of the tenants in using the readings of the system to regulate their electricity usage had a mean of 4.26, which can be described as Agree. The overall mean of 4.3 which is also defined as a kind of agreement shows a factual balance of the correctness of the system in the eyes of the tenant. Combined, these findings suggest that the system has already gained some credibility amongst its end consumers, and tenants are convinced that the data being displayed to them is an accurate and reliable representation of their actual electricity usage and as such is a valuable instrument of personal energy management.

Software and Hardware Design Discussion

Electricity Misuse Detection with PZEM Anomaly Detection and Notification system, is a system that is designed to detect and monitor electricity misuse using a combination of embedded software and hardware and intelligent software algorithms. The hardware part of the system cooperates to gather, operate, and transfer data on electricity consumption, in which the PZEM is the main energy measuring device, which measures the most important electrical parameters of voltage, current, power, and energy consumption in real-time. The received data is in turn processed by the Arduino R4 which serves as the core microcontroller that is in charge of sensor data retrieval as well as control of data flow within the system. The ESP32 module is used as the wireless communication, and it allows transmitting data over long distance of the electric data being monitored to the other end of the network, it provides LED indicators that give instant visual visualization when anomaly or abuse of electricity is detected. On the computer side, the system was built on PHP, as the main server-side scripting language and MySQL as the database management system (DBMS) to store and manipulate the records of electricity consumption and the logs of the system to enable the administrators to monitor real-time energy consumption, see the past-recorded consumption and easily manage the system settings using a browser. When the system notices any anomaly or electricity misuse, an SMS alert is automatically notified to the appointed administrator or user, so that relevant people are advised about any unusual occurrence immediately so that they can take suitable measures to control any possible electricity misuse.

Context diagram of the Electricity Misuse with PZEM

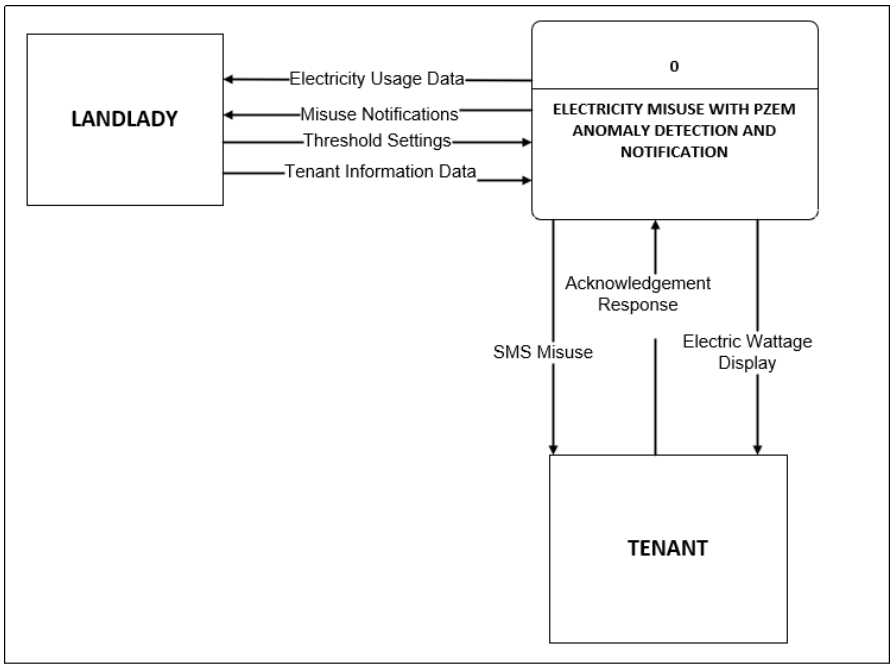

Figure 1: Context Diagram

Anomaly Detection and Notification system is provided to show how data move between the two external parties, the Landlady and the tenant, and the system itself. When the Landlady enters data as inputs into the system, the information she provides to the system includes tenant information and threshold settings, whereas the data the system provides to the Landlady includes electricity usage and misuse alerts to keep the Landlady updated on the current state of consumption and any irregularities that may have been detected.

The figure presents Data Flow Diagram (DFD) of the

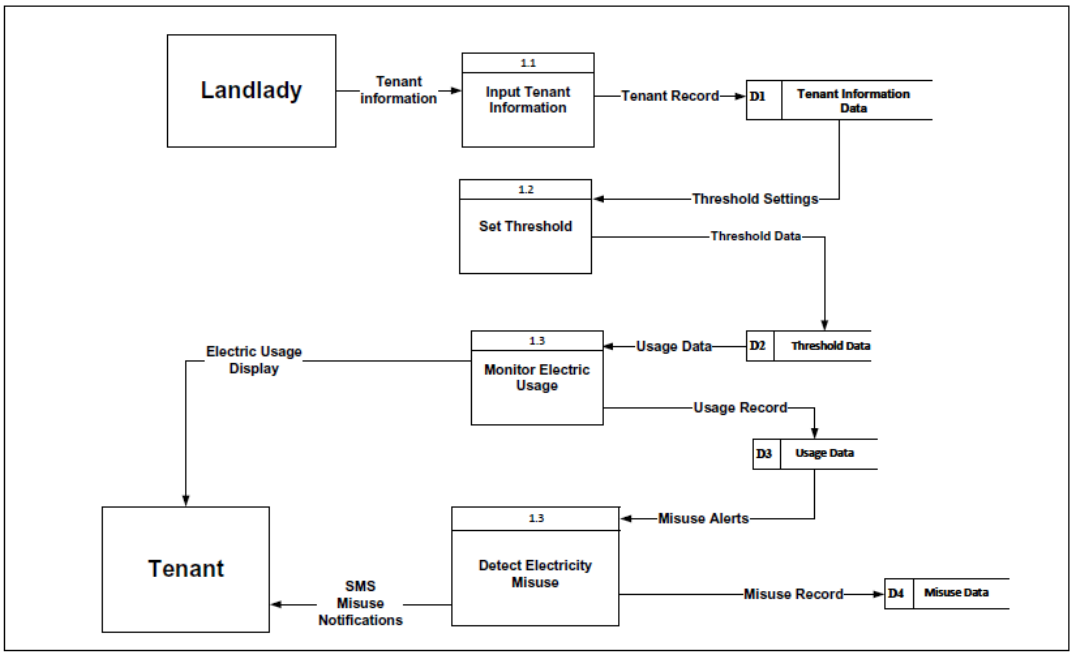

Figure 2: Data Flow Diagram

Electricity Misuse with PZEM Anomaly Detection and Notification System. It draws a diagram of the flow of data between the users, system processes and data storage. The Landlady would start with tenant information inputting process under Input Tenant Information (1.0) procedure that would be stored in the Tenant Information Data Store (D1).

Another threshold which is saved in Threshold Data Store (D2) is the landlady limiting the electricity usage to a set threshold (Set Threshold 1.1). This system then gathers and logs the usage of electricity constantly and uses Monitor Electricity Usage (1.2) records the usage logs in Usage Data Store (D3).

The diagram shows the hardware design of electricity

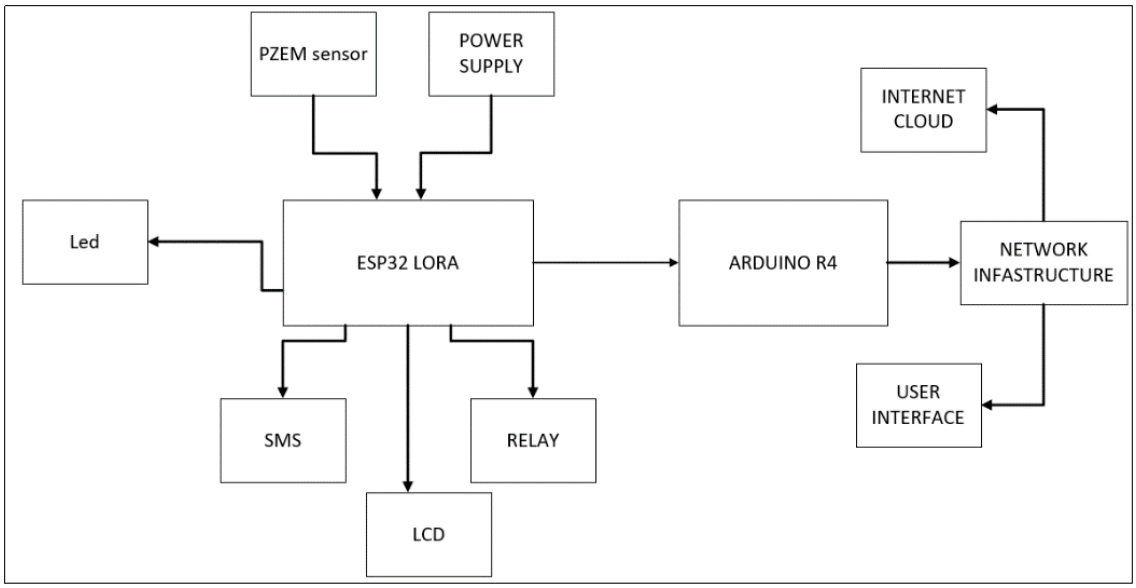

Figure 2: Block Diagram

misuse monitoring system and the interaction of the various components with one another. The first part of the process is the PZEM sensor that detects electrical parameters and transmits the gathered information to the ESP32 module. The system depends on the power supply to provide the power needed to run the system. The ESP32 is used as a central communication and control point, which will accept the sensor data and process a few output elements. Depending on the condition of the system, it will be able to use the buzzer and LED to create warning signals, display data via the LCD, send notifications via SMS, and regulate the flow of electricity with the help of a relay. The processed information is then sent to the Arduino R4 that processes the system and sends the data to the network infrastructure. The data is sent to the internet cloud where it is stored and monitored and can also be accessed by the users through the user interface. In general, the block diagram indicates the flow of data through sensing element by processing and alert systems to the network to enable monitoring and control of electricity consumption.

CONCLUSION

The study was able to successfully develop the Electricity Misuse with PZEM Anomaly Detection and Notification System that enhances electricity monitoring in order to detect electricity misuse (abnormal energy consumption) in rental apartments. This system could track the electricity consumption, trigger alerts via ESP32 module, and offer a more streamlined and automated solution than manual monitoring. It also enabled landlords to easily monitor electricity use and also motivated tenants to use electricity responsibly by providing them with timely reminders. The project emphasized the need for wireless communications and automated monitoring technologies for enhanced electricity management. In general, the system was found to be useful, reliable and effective to minimize unnecessary over-consumption and facilitate electricity monitoring in apartment buildings. Future researchers can further enhance the system in other environments like dormitory, school, or commercial building, and provide other functions such as advanced analysis, automated billing, multiple user accounts, or mobile application for convenience and monitoring.

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