POWERSYNC: OPTIMIZING ENERGY MONITORING THROUGH ARDUINO AND RASPBERRY PI SERVER-BASED CONTROL SYSTEM

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The Researchers

DEDICATION

The researchers dedicate this work to the individuals who provided their guidance and support, which contributed to the completion of this study.

To my beloved family, parents, grandpa, and friends, your unchanging love and moral support have carried me on this path with determination. Thank you for your unending encouragement of praise, continuous patience during these times, and showing spirit and integrity to finish. Thank you. – Gabrielle

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ABSTRACT

The study focused on the development of a Windows application and a private website for energy monitoring and control. The Windows application is designed to monitor and control electrical loads within the TTBDO. In contrast, the private website is designed to display statistical reports of energy consumption within a certain amount of time. The study also focused on the development of an IoT system using Arduino and Raspberry Pi, as well as a scale model for the TTBDO. The primary objective of the study is to develop an integrated Arduino and Raspberry Pi system that can connect hardware components with software controls through communication protocols while providing users with status updates about energy consumption via the website. The proposed project is a Windows App that can monitor and control active loads on a miniature scale of the TTBDO and a website that displays energy consumption. The methodology employed uses AGILE development for prototype as well as system design and testing to ensure that the system works as designed. Results state that the developed Arduino and Raspberry Pi control and monitoring system using Node-RED, MQTT, and TCP/IP protocols successfully connects both hardware and software components of the research and the UI is user-friendly. This concludes that the system successfully links Arduino and Raspberry Pi communication to the hardware components through a LAN connection, which utilizes Node-RED and MQTT protocols, resulting in an operational and scalable monitoring and control system.

Keywords: Windows app, website, energy monitoring and control, Raspberry Pi, Arduino

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CHAPTER I
INTRODUCTION

Background of the Study

Electricity is one of the most valuable resources that we use daily, especially in the modern era, yet it's worth the most expensive. As technology progresses into more complex designs and a variety of electronics continue to be developed, the use of energy in using these technologies grows at a rapid rate. The rapid depletion of resources is where there should be an urgent shift to renewable energy sources. Nowadays, with the expansion of buildings, institutions, and other infrastructures, there is an immediate demand for an increase in energy. Hence, the need to monitor and control such factors is a determining factor in creating sustainable energy consumption.

Energy management is the systematic and cautious monitoring, control, and optimization of an institution or organization's energy consumption to conserve use and decrease energy costs. It includes monitoring monthly energy-generated bills. The impact of the HVAC (heating, ventilation, and cooling) system comprises approximately 40% of total building energy consumption and 70% of the base building energy consumption. HVAC is also a major energy consumer in non-residential buildings. (DEE, 2013) With this, energy management can be useful in improving HVAC equipment that is fully utilized and better-correcting energy performance. It is essential in creating financial projections for commissioning energy-saving policies and reduced energy costs.

Approximately 66% of the world's energy production is wasted, making energy waste a significant contribution to greenhouse gas emissions. Inefficient appliances, insulation, transportation, and industrial processes cause excess CO_2 emissions, resource depletion, and environmental harm. Millions of tons of CO_2 are released every day worldwide from the waste of coal-based electricity alone. Cutting down on energy waste can save money, cut emissions, and lessen pollution and habitat loss (Ukpanah, 2024). Cutting down on energy waste can save money, cut emissions, and lessen pollution and habitat loss.

There is a rise in electricity usage and prices in the Philippines. An article by GMA News Network stated that Meralco announced that customers should expect higher electricity bills in September 2024 because of rising transmission costs. The electricity rate is increasing by P0.1543 per kWh, bringing the typical household rate to P11.7882 per kWh from August's P11.6339. This change will mean an additional P31 for a household consuming 200 kWh. Meralco explained that the rise is due to a P0.2913 per kWh increase in transmission charges, largely driven by higher ancillary service fees after the Reserve Market resumed operations in early August.

ISO 50001 is an international standard aimed at improving energy management practices, reducing resource consumption, and enhancing financial performance. It provides a framework for developing energy policies, setting targets, using data-driven decision-making, and continuously improving strategies. Certification is optional, but organizations can implement it for internal benefits or external stakeholders. ISO 50001 aims to improve energy efficiency, reduce operational costs, and contribute to environmental conservation goals (*ISO - ISO 50001 — Energy Management*, 2023).

A study developed a web-based electricity consumption monitoring system for a university using the waterfall software development methodology. The system enables real-time monitoring of electricity usage and is currently operational and accessible. It highlights the importance of ISO 50001, an international energy management standard that provides corporate and technical methods for reducing costs, improving energy efficiency, and enhancing environmental performance. Additionally, the study emphasizes how Internet technology can facilitate open monitoring of electrical energy consumption (Akbar et al., 2023).

Arduino, an open-source electronics platform, is based on software and hardware that are easy to use. Arduino boards can transform inputs into outputs, like turning on a motor, an LED, and other components. The microcontroller on the board can be programmed by giving it a set of instructions. This is done using the Arduino programming language, which is based on Wiring, and the Arduino software (IDE), which is based on processing.

The Raspberry Pi is a compact, low-cost computer that connects to a monitor or TV and uses a standard mouse and keyboard. It runs on Linux-based Raspberry Pi OS and can perform tasks like browsing the internet, streaming HD videos, and handling productivity tools. It's often used in DIY projects like music systems and weather stations. It's widely used for learning programming and understanding computer systems but lacks built-in storage. It has Bluetooth, Ethernet, and Wi-Fi capabilities for internet file sharing.

This study will utilize relays to serve as panelboards and Arduino to control smart electrical components through custom-developed software. The relay will manage the electrical distribution, while the Arduino microcontrollers will interface with the smart components, executing commands and controlling their behavior. A Raspberry Pi will serve as the central server and will handle processing. This setup will allow for efficient communication between the software, Arduino, and smart devices, facilitating automation and intelligent management of the system.

The researchers came up with the idea of integrating hardware and software capable of monitoring whether a room is using electrical components and will be able to control it through a LAN connection. It includes a centralized Windows app system where data can be monitored and can be controlled locally. Microcontrollers are connected via an ethernet switch mesh net to create a secure and centralized system to monitor the building.

To put it concisely, the project will create a private website for the stakeholders to view and a dedicated Windows-based app monitoring control system to aid the university's school guards in reducing energy consumption. The design comprises visualization of data for monitoring and safe control of electricity from a specific position. It also provides the status of where electricity is being used. This study aims to help school administrations, homeowners alike, and other consumers to actively control, monitor, and aid in the formulation of energy-saving policies.

Arduino-Based Monitoring

The paper focuses on developing an Arduino-based energy monitoring system that provides precise and timely energy consumption data. This system is essential for energy-saving strategies and building management. It enables users to monitor habits, predict future consumption, and ensure energy awareness through real-time data display. The conclusion suggests that the system can evolve into a more comprehensive building energy management solution, integrating AI and supporting multiple communication protocols for enhanced decision-making and energy efficiency (Degha et al., 2019).

An Arduino-based electrical panel board that can be viewed and controlled via Wi-Fi enabled mobile application was developed by Rosario et al. (2023). The project system is controlled by an Arduino Uno and is monitored by an Arduino Mega. Blynk IoT is the application used to provide the system's interface and notification functions. The system demonstrated complete operating capabilities and attained a no-error rate. The researchers concluded that some of the future improvements should include manual switches, an I2C LCD screen, EEPROM storage, current transformers, voltage fluctuation prevention, and power bill computations.

A study by Gomez et al. (2023) developed a program using an application to monitor and control lights, outlets, orbital fans, and special-purpose outlets in a classroom. Security guards can use the application to control these devices remotely using the Internet of Things. The study evaluated the accuracy of the application for measuring voltage and current using the PZEM-004T device and found that it is highly accurate. The study concluded that the program successfully leverages Internet of Things technology to control and monitor classroom devices.

This study presents an innovative approach to home energy management by integrating an Arduino microcontroller with relays and transistors to control various electrical appliances, including lamps, fans, and air conditioners. The Arduino serves as the central controller, interfacing with a PIR sensor for the lamp and fan and a temperature sensor for the air conditioner. This system enhances energy efficiency by optimizing the operation of these appliances based on occupancy and environmental conditions. Results indicate that the implementation of this Arduino-based system can achieve energy savings of at least 1.5% by intelligently managing the consumption of electrical appliances. Furthermore, the proposed system is adaptable for use in small-scale office buildings, showcasing its potential for broader applications in energy management. (Ramli et al., 2014)

Smart Monitoring through IoT

A smartphone app developed by Kassim et al. (2018) to monitor the amount of electricity consumed on a college campus. Five buildings were installed with smart meters, enabling the collection of usage data every fifteen minutes. The program, created by Live Code, allows users to track changes in energy use graphs. Data showed that there was a considerable difference in energy consumption between working and non-working hours, with midday being the peak demand.

The research focuses on developing a centralized smart energy monitoring system for legacy home appliances to optimize energy use. By providing real-time data, the system helps track energy consumption patterns and identifies inefficiencies in older devices. The conclusion highlights its cost-effectiveness, making it a practical solution for households without smart appliances. This system can contribute to reducing energy waste and supporting sustainability efforts by extending energy monitoring capabilities to non-smart home environments. (Ahmad et al., 2024)

A study by Park et al. (2019) suggests a wireless network-based monitoring and control architecture for smart lighting systems. The architecture consists of radio access modules and a mobility service for internet connectivity. High-speed data transfer, request/reply control, and periodic status reporting are made possible by mobile devices that use the ISM band. The main controller's frames and processing functions provide event reporting. The researcher concludes that the suggested design provides a practical and affordable option for smart lighting systems. Bluetooth mesh networks should also be taken into consideration in the future to enhance scalability and communication.

The Internet of Things (IoT) facilitates the management and tracking of electrical and mechanical equipment through an accessible graphical user interface (GUI). This project focuses on developing an IoT system for monitoring energy consumption and managing billing processes, which traditionally require manual meter readings, posing challenges in accuracy and efficiency. The proposed system integrates an energy meter with a microcontroller to monitor electrical usage and transmit data, along with the corresponding bill, via a Wi-Fi network. Users can conveniently track their energy consumption and costs through the Blink IoT application from any location. The system employs a Node MCU and an IoT-enabled energy meter, which enhances accuracy in meter readings and billing while minimizing human intervention. This innovation leads to reduced operational costs and improved transparency in billing. The energy meter displays kilowatt-hour consumption on an LCD, and the continuous monitoring and data transmission to a central server provides users with real-time access to their energy usage information. Additionally, the system can incorporate features for detecting power theft and automatically cutting off power, further enhancing its functionality and security. (Lalitha et al., 2023)

Raspberry Pi Smart Monitoring

The study proposes a system to minimize energy waste and enhance safety by automatically managing household appliances. Using Bluetooth signals from devices like phones and fitness bands, the system detects when users leave their homes and switch off unnecessary appliances such as lights and fans. It supports multiple devices, allowing manual control when users are present, and reduces the risk of electrical fires by ensuring appliances are off in the user's absence. The system uses a Raspberry Pi; the system can also be upgraded and integrated with IoT for real-time power monitoring, offering a practical and scalable solution for energy conservation and safety (Poorvi et al., 2016).

A study by Kumar et al. (2024) aimed to create an IoT-based web-enabled system for monitoring residential electricity consumption. The study incorporated components such as Raspberry Pi Pico, current coil, relay, energy meter (PZEM004T), ESP8226, LCD, and RFID, the real-time energy tracking system via a web interface. It calculates electricity costs based on consumption and displays them on an LCD screen. Additionally, it detects power theft, notifies the users through a web server or mobile app, and includes an RFID-based prepayment feature to track user payments. By wirelessly transmitting and analyzing data while managing power supply through relays, this secure and cost-effective solution helps reduce electricity bills and supports sustainable energy practices.

This study overcomes the challenges of traditional domestic energy meter systems like limited bandwidth, low efficiency, lack of real-time data, and no two-way communication by introducing an IoT-based Automatic Meter Reading (AMR) system using Raspberry Pi microcontroller. The system tracks power fluctuations with voltage and current sensors. It also automatically controls household devices based on the power supply and communicates consumption and billing details to consumers through the Internet. Users can access real-time billing information via an AMR server, and the system also detects tampering and theft. AMR eliminates the need for manual meter inspections, reduces operational costs, ensures accurate billing, and improves customer service (Devi et al.,2019).

A study conducted by Purwania et al. (2020) indicated that effective energy management through IoT technology offers a potential solution to environmental damage and global warming by monitoring energy consumption. IoT has been applied in Smart Homes, Buildings, Metering, and other fields. These infrastructures commonly use cost-effective microcontrollers and cloud-based platforms.

This study focused on developing a web-based energy monitoring system for residential electricity use, utilizing IoT technology and hardware such as Raspberry Pi Pico, LCD, current coil, PZEM004T energy meter, ESP8266, and RFID. The system enables real-time tracking of energy consumption, providing users with insights into their habits and ways to lower electricity costs. It also calculates the electricity rate based on usage and displays it on the LCD screen. The current coil detects power theft and sends alerts through a web server or mobile. An RFID tag is used for payment, showing the amount paid. (Saranraj et al.,2023)

Node-RED and MQTT Prototyping

Created by IBM Emerging Technology Services, Node-RED is a flow-based programming tool that is currently a part of the OpenJS Foundation. It offers a browser-based flow editor that facilitates the process of connecting flows by utilizing the palette's extensive selection of nodes. Then, with just one click, flows may be deployed to the runtime. A rich text editor can be used to construct JavaScript functions inside the editor. You can store helpful functions, templates, or processes for later use using an integrated library (*OpenJS Foundation & Contributors, n.d.*).

Message Queuing Telemetry Transport (MQTT) protocol is a lightweight messaging protocol designed for machine-to-machine (M2M) communication in low bandwidth environments (Steve Cope, 2021). Originally designed for oil pipeline telemetry systems, MQTT is increasingly used and has evolved as a solution for IoT applications. MQTT is used in various cases and industries, from automotive logistics to Smart Homes and Energy. The Case Study conducted by Cirrus Link Solutions details how a multinational energy corporation modernized its operations by maximizing the use of MQTT protocol alongside the SCADA platform and effectively monitoring and collecting the operational technology data. (Cirrus Link Solutions, n.d.).

A study by Ferencz et al. demonstrates that Node-RED and MQTT protocols offer significant advantages over traditional industrial solutions, enabling rapid prototype development, efficient data visualization, and streamlined business logic creation. Despite initial implementation costs, IIoT (Industrial Internet of Things) optimizes industrial processes through interface extensibility and predictive maintenance capabilities. The combination of these technologies facilitates effective data collection, analysis, and visualization with minimal development work, helping industries remain competitive in a rapidly evolving technological landscape.

An integration of Node-RED with IoT analytics to handle large amounts of data generated by IoT devices demonstrates how it reduces development time, simplifies data flow design, and enables effective visualization of complex information. It highlights the potential of integrating visual programming tools with advanced analytics in the IoT domain. It suggests future research directions to enhance the performance and reliability of IoT data processing systems (Onwuegbuzie et al., 2024).

A study by Thomas et al. (2024) presents a low-cost home automation system using the Internet of Things (IoT). It uses Node-RED for IoT development, wireless sensor network (WSN) technology for data upload and MQTT protocol for communication. The system allows remote operation of home devices and sends notifications via email, promoting home automation.

Based on the comparison in Table 1, the researchers decided to use hardware components such as the Arduino UNO R3 paired with an Arduino Shield with the addition of Raspberry Pi 4, as these were also utilized in related studies. This study aims to integrate a web-based system for monitoring as well as a Windows app for controlling electronic components in a building. The study also integrates Raspberry Pi as the main server platform. According to an article by Nick (2024), Raspberry Pi is versatile and often preferred in IoT product development due to its compatibility with a wide range of sensors, actuators, and accessories. This versatility makes it the ideal choice for this research. Additionally, it can run on both Raspberry Pi OS and Windows and offers built-in Ethernet and Wi-Fi for seamless connectivity.

Synthesis

The researchers thoroughly examined different approaches to integrating Arduino for smart energy monitoring and IoT control (Refer to Table 1). Drawing from related studies, it is highlighted that Arduino-based systems are already in use worldwide, showing the technology's growing adoption in energy management. However, each system presents unique strengths and weaknesses, which the researchers compared to those of similar systems and studies. This comparison helped to identify the best practices and potential improvements, providing a comprehensive understanding of how different Arduino configurations perform in real-world energy monitoring scenarios. Through this analysis, the researchers aim to contribute to the development of more efficient, scalable, and cost-effective smart energy solutions.

Conceptual Framework

As shown in Figure 1, the researchers will create the software needed to process the MQTT messages sent to the system via Publish and Subscribe as the Arduino ethernet shield as a client and Raspberry Pi as a broker connection. The MQTT messages will contain the data and information to be sent to the Arduino Uno, which is connected to a relay board that will control electrical loads in the building. A Raspberry Pi is used as the server handling web hosting and database management to act as the central node in the IoT system and as the MQTT Broker. Its low power consumption and flexible software make it ideal for this project. For the software, the researchers used LAMP stack (Linux, Apache MySQL, and PHP) Linux as the foundation for the Raspberry Pi Server, Apache to handle web service, MySQL for the database, and PHP as the backend. Node red was also installed in the Raspberry Pi as the bridge connection between hardware and software. The front-end website design used HTML, JavaScript, and CSS to develop the website. C# for the Windows App and

Arduino IDE for programming Arduino. The private website is used to display energy consumption and statistics to administrators and other stakeholders.

Figure 1

Conceptual Framework

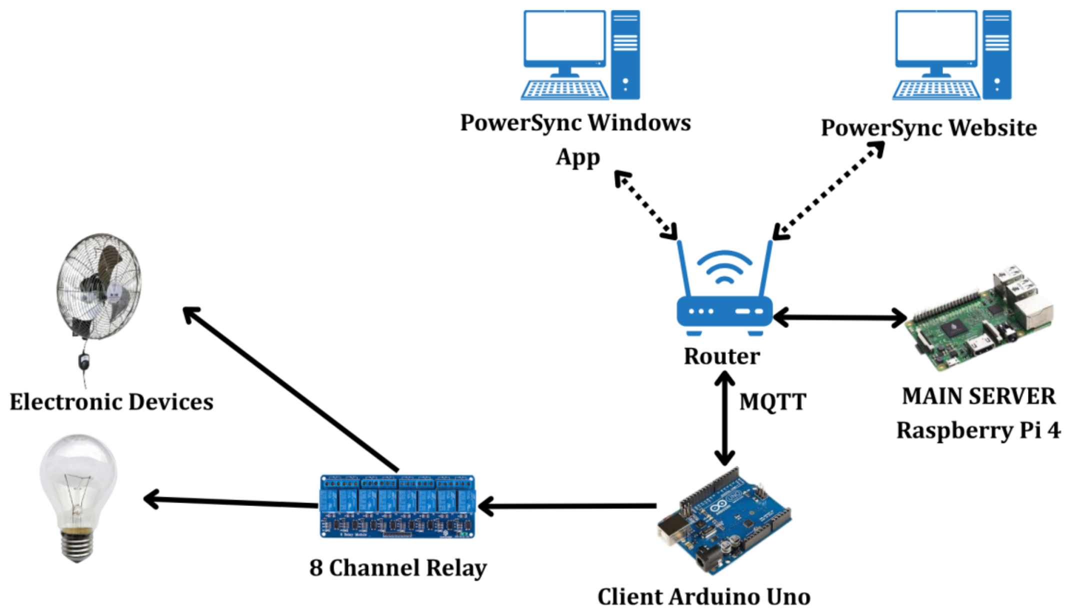
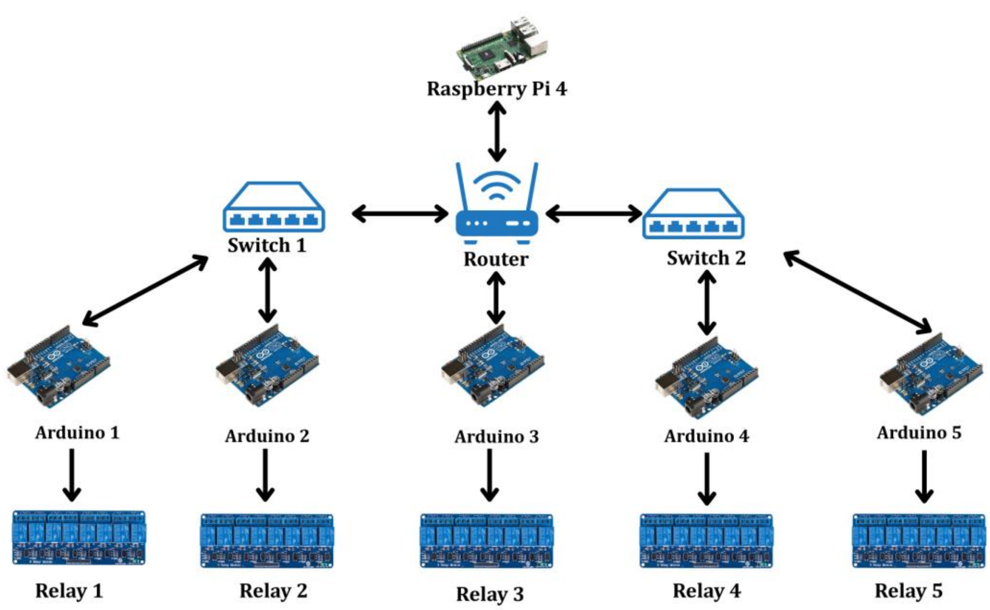


Figure 2
Conceptual Framework for Scalability



Arduino IDE and Node Red are implemented for the IoT control and an MQTT connection for the Windows app that controls the hardware via LAN connection. All the data that are sent and received by the system is relayed in Node-Red via the publish and subscribe protocol. Another node is used to connect to the Raspberry Pi

MySQL Server. It is saved on a micro-SD card stored in the Raspberry Pi for backup and future access.

The system's scalability (Figure 2) allows for effective control of electrical loads across any building when Arduino controllers and relay boards are connected to switches linked to the main router and Raspberry Pi server. For new buildings, administrators need to add the building's layout to the Windows application's control panel, enabling seamless remote management without extensive reconfiguration.

Analytical Framework

Figure 3 shows the system's analytical process. The inputs are the MQTT messages sent out to the connected electrical loads to the Arduino and received by the system. The MQTT messages are then sent to the router via TCP/IP and received by the MQTT broker via Node-Red to store the data on the MySQL Database. Information from the database is saved to a microSD card. The expected output is to display energy consumption to the administration through the website, as well as monitor and control it via the Windows app, which can also be accessible to the university guards.

Figure 3

Input, Process , and Output Diagram

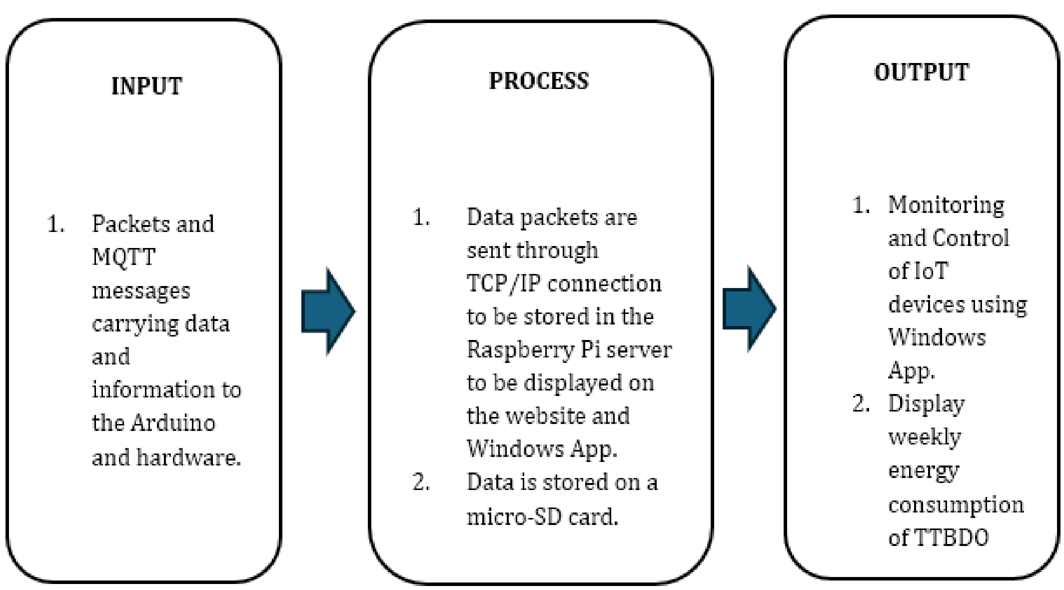


Table 1
Comparison of the Study Among other Related Studies

	Arduino-Based Control and Monitoring of Electrical Panel Board	**Control and Monitor of Electrical Loads in a Classroom using IoT Technology**	**PowerSync: Optimizing Energy Monitoring through Arduino and Raspberry Pi Server Based Control System**
Microcontroller	Arduino Mega 2560 Arduino UNO R3	PZEM-004T	Raspberry Pi 4 Arduino UNO R3
Program & Platform used	Arduino IDE Blynk Server IoT	Blynk Server IoT	Visual Studio 2022 Visual Studio Code Node Red LAMPP Stack Arduino IDE
Modules	Relay Module Wi-Fi Module	Relay Module Wi-Fi Module	Arduino Ethernet Shield
Operation	Monitoring & Controlling	Monitoring & Controlling	Monitoring & Controlling
Connectivity	Wi-Fi	Wi-Fi	LAN Ethernet
Control or Monitoring System	Mobile application & Web based	Mobile Application	Web based & Windows App

Statement of the Problem

This study seeks to address unmonitored energy consumption by implementing an Arduino-based monitoring and control system that is accessible via software developed by researchers. To achieve this objective, the following questions were posed:

1. How can an Arduino and a Raspberry Pi server-based monitoring and control system be effectively integrated with software?
2. Is it feasible to establish a connection between software controls, Arduino, Raspberry Pi, and the associated hardware?
3. How will the system communicate information about the status of the electrical components to the user?

Scope and Delimitations

Scope

For the system to operate effectively, it necessitates the use of programmed inputs and microcontrollers. The development will utilize a Raspberry Pi as the core platform and Arduino together with an 8-channel relay board as panelboard controllers, allowing for seamless control of electrical components throughout the system. A Windows app is designed to feature a simple TTBDO. The university administration and university guards will be able to access the Windows app to monitor and control the electrical loads within the TTBDO. A private website is designed to enable the university administration and stakeholders to view energy consumption within a certain amount of time.

Delimitations

The prototype focuses on the development of the User Interface (UI) for the Windows app and the private website using Raspberry Pi as its server and a prototype to implement control of electrical loads. The Windows app's primary function will be to monitor and control electrical loads. The website will be used to display and provide a summary of weekly electrical consumption within the TTBDO building.

CHAPTER II

METHODOLOGY

Research Design

The research design for this study would implement the software prototyping methodology, specifically Systems Development Life Cycle (SLDC), specifically AGILE methodology (Refer to Figure 4), which is a more formalized process, flexible and collaborative in handling projects where integrity and functionality are vital for the project to succeed. The study is a collaboration between the Computer Engineering and Electronics and Communication Engineering teams; it is only logical to implement AGILE as the software development methodology. Under it, there are phases or stages which the researchers will utilize to assemble the software system.

Figure 4
AGILE Development

Research Locale

The prototype will be conducted at Saint Mary's University, Bayombong, Nueva Vizcaya, and the system will be implemented at the School of Engineering, Architecture and Information Technology (SEAIT) TTBDO. The prototype aims to monitor the existing nodes of electrical loads and controllers using a Windows application and website for statistical graphs displaying the power, voltage, current, and electrical consumption.

Data Gathering

The researchers gathered data by sending online surveys to determine the usability and user-friendliness of both the Windows App and website. Sensor readings from the ECE group's Watcher, as well as server logs, are the primary sources of data to be displayed on the application and website. The sensor from Wattcher uses Arduino to monitor energy consumption, which is connected to a router via a LAN and then sent to the Raspberry Pi, which stores data in the MySQL database. Transmission accuracy of data would be tracked by logs, as well as system response times. At the same time, feedback from the online surveys provides qualitative insights into the system's usability and functionality. Together, this information will guide the researcher's evaluation of the prototype and assess the necessary final adjustments.

Table 2
Hardware Description

Component	DESCRIPTION
Raspberry Pi 5	Main database server this is where all the information collected from the sensors is going to be stored.
Router TP-link	Connects the devices to a network and sends the data through the network system.
Arduino Uno	Controls the electrical loads and sends data on the status of active components to the system.
8 Channel Relay Board	Acts as a panel board to the system. Controls components based on the message sent by the Arduino.

Research Instruments and Design Tools

This study focuses on integrating and bridging hardware components (Refer to Table 2) to develop software for energy monitoring. The key elements include an Arduino and a relay board, which will control the IoT components and send feedback messages on their status. The Arduino is programmed with an MQTT Client script to connect with the Raspberry Pi broker and store data in the MySQL database. Additionally, a Windows-based application, paired with a private web interface, allows users to control and monitor respectively to manage energy use efficiently. This setup instrumentation facilitates data acquisition, monitoring, and effective visualization of electrical components, supporting energy-saving strategies and informed decision making.

Table 3
Software Description

SOFTWARE	DESCRIPTION
LAMP Stack	This is main backend and a PHP framework language which is lightweight server language that will be used to connect between database languages. This allows to efficiently store and retrieve critical data collected by the hardware sensors.
Database Management System	MySQL is to store and manage sensor data such as electrical loads, power, voltage, current and electrical consumption from the system.
JavaScript	This can be used to develop frontend of the website
Visual Studio Code (VSCode)	Main coding IDE for web development.
C# in Visual Studio	This is used to develop the desktop application of the system.
Node-RED	This is used to connect the hardware to the software using flow connections in which Raspberry Pi is utilized.

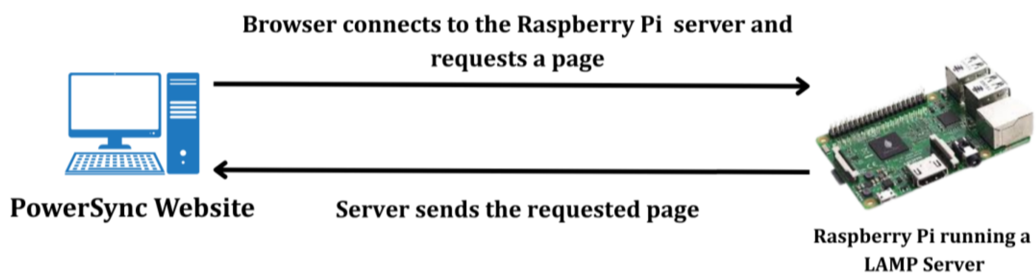
Software Description

The energy monitoring system is designed to control electrical loads within the TTBDO and visualize power consumption based on the data sent by the sensors. It has key features for displaying graphical data of the factors. It provides data analysis in which users can view past energy consumption. The energy monitoring system is web-based and has a Windows application for control, which there are varying levels of user management.

The architecture follows a client-server wherein backend server languages such as PHP are used to handle server-side logic and process database instructions and interactions. MySQL will be utilized with the following LAMP as a web server (Refer to Figure 5). The front-end dashboard will be built using JavaScript, HTML, and CSS for data visualization using Charts JS and Scott Plot, and the desktop application will use C#(Refer to Table 3).

The software uses the scalability of Node-Red built-in functions while securing Raspberry Pi to encrypt between client and server sensor data. Overall, the scalability of the software and hardware can be integrated and accommodated in multiple buildings.

Figure 5
Apache Connection



Cost Analysis

This table shows the estimated cost of the materials that would be used in conducting the study. The Raspberry Pi server serves as the most valuable item in research, along with other networking materials. Thus, this table represents the value cost of the research conducted (Refer to Table 4).

System Architecture

This system architecture illustrates the process of using the system from the administrators, Security Guards, and SEAIT Dean/Dept. Heads. The Administration and Security Guards can control the energy consumption of the TTBDO (Technology Transfer and Business Development Office) via the Windows App. The SEAIT Dean and Dept. Heads can view the PowerSync private website, and administrators can do so as well (Refer to Figure 6).

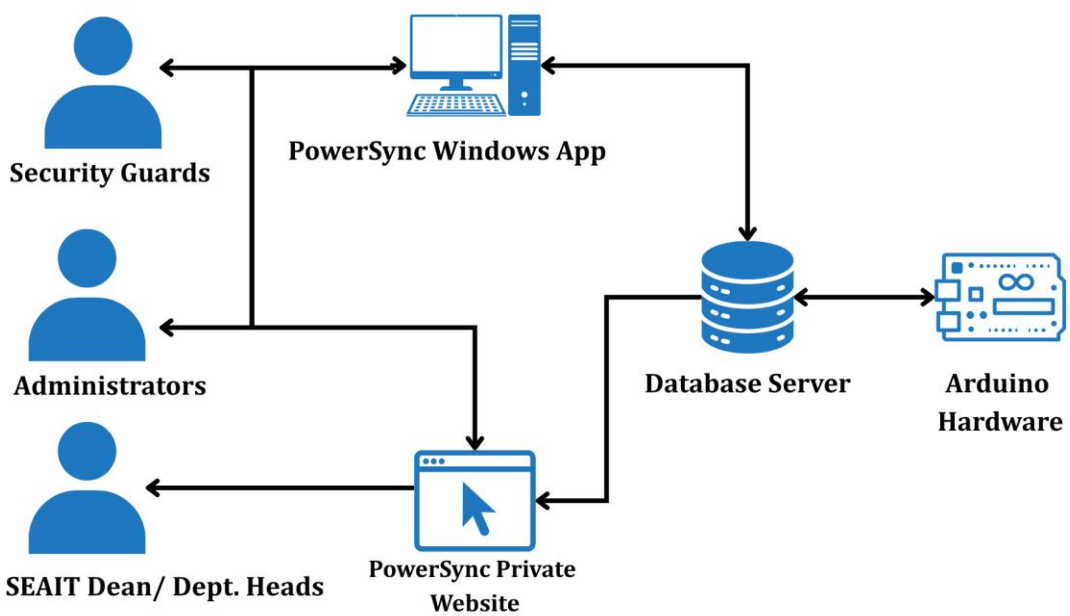
The System will only be used within Saint Mary's University, more specifically within the TTBDO. The PowerSync Windows app would operate using a Local Area Network (LAN), while the private website would utilize Raspberry Pi.

The university administration can use the website interface, as well as the dean and department heads of SEAIT. The researchers, who are also the administrators of the website, will create the stakeholders' profiles and provide them with their accounts and passwords. To access the website, they must first open a web browser and access the login interface of the PowerSync Website. Then, they will have to enter their account name and password, after which they will be redirected to the main interface of the website. Both the admins and stakeholders can view the Dashboard and Statistics page. However, only the system admins can access the user page to ensure that only authorized personnel are allowed to access the website (Refer to Figure 7).

Table 4
Cost Analysis

Main Hardware Component	Quantity	Price(Pesos)
CanaKit Raspberry Pi 4	1	P8,500.00
Router – tplink	1	P650.00
Ethernet Shield	1	P800.00
8 Channel Relay Board	1	P200.00
Raspberry Pi & Arduino Holder	1	P410.00
		P10,560.00

Figure 6
System Architecture



Both the university administrators and the Security Guards can access the PowerSync Windows App. The same accounts given to the administrators can be used to log in to the PowerSync Windows App. In contrast, a separate account will be created for the Security Guards. After the users have logged in to the main interface, they will be given access to the Dashboard, where statistical data such as current active loads of the system, weekly consumption, and a graph of hourly consumption will be provided. The users will also be given access to the Control Interface, which will redirect the user to the layout of the building, indicating which rooms have active electrical loads and control those components remotely (Refer to Figure 8).

Figure 7
PowerSync Website Flowchart

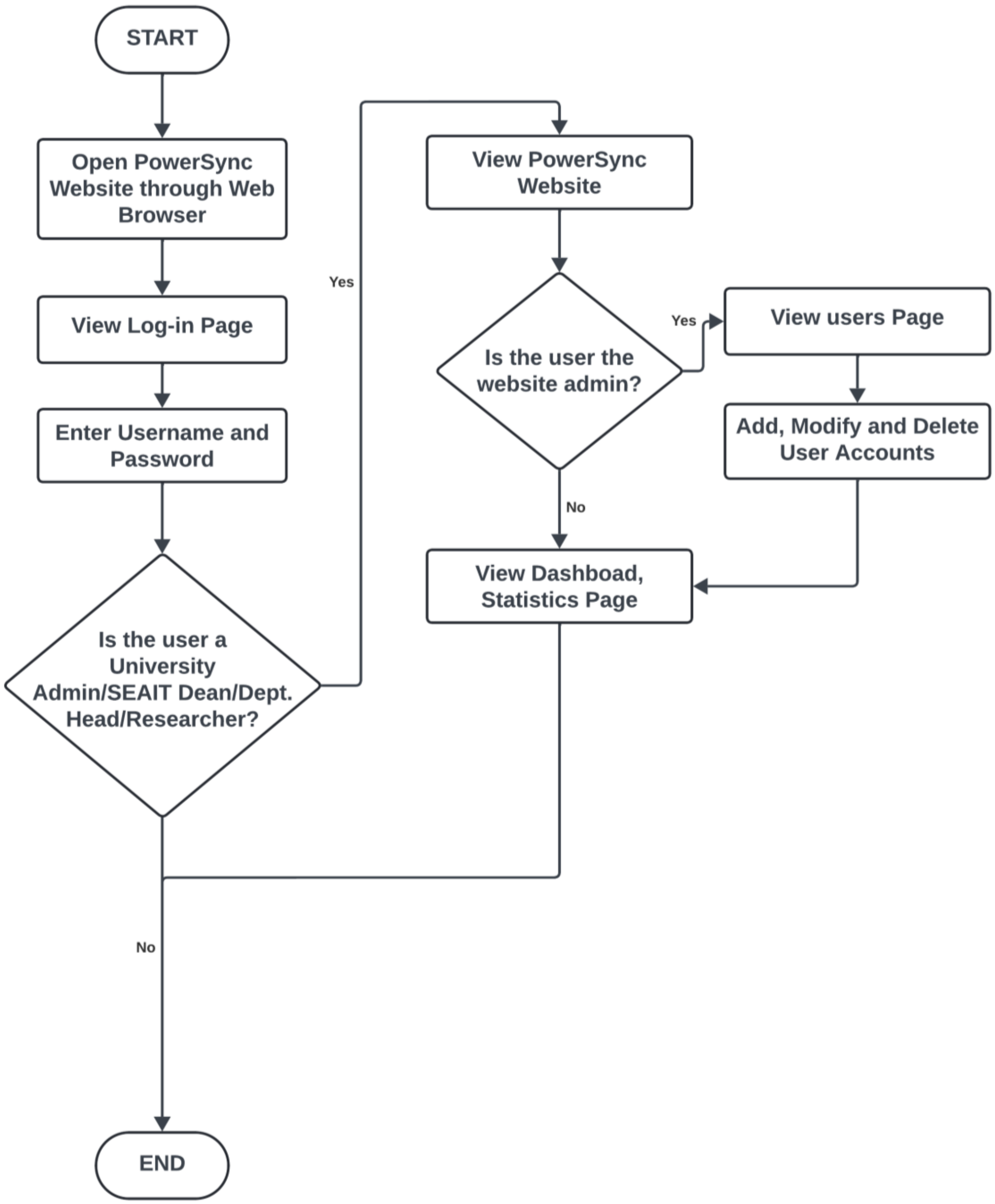
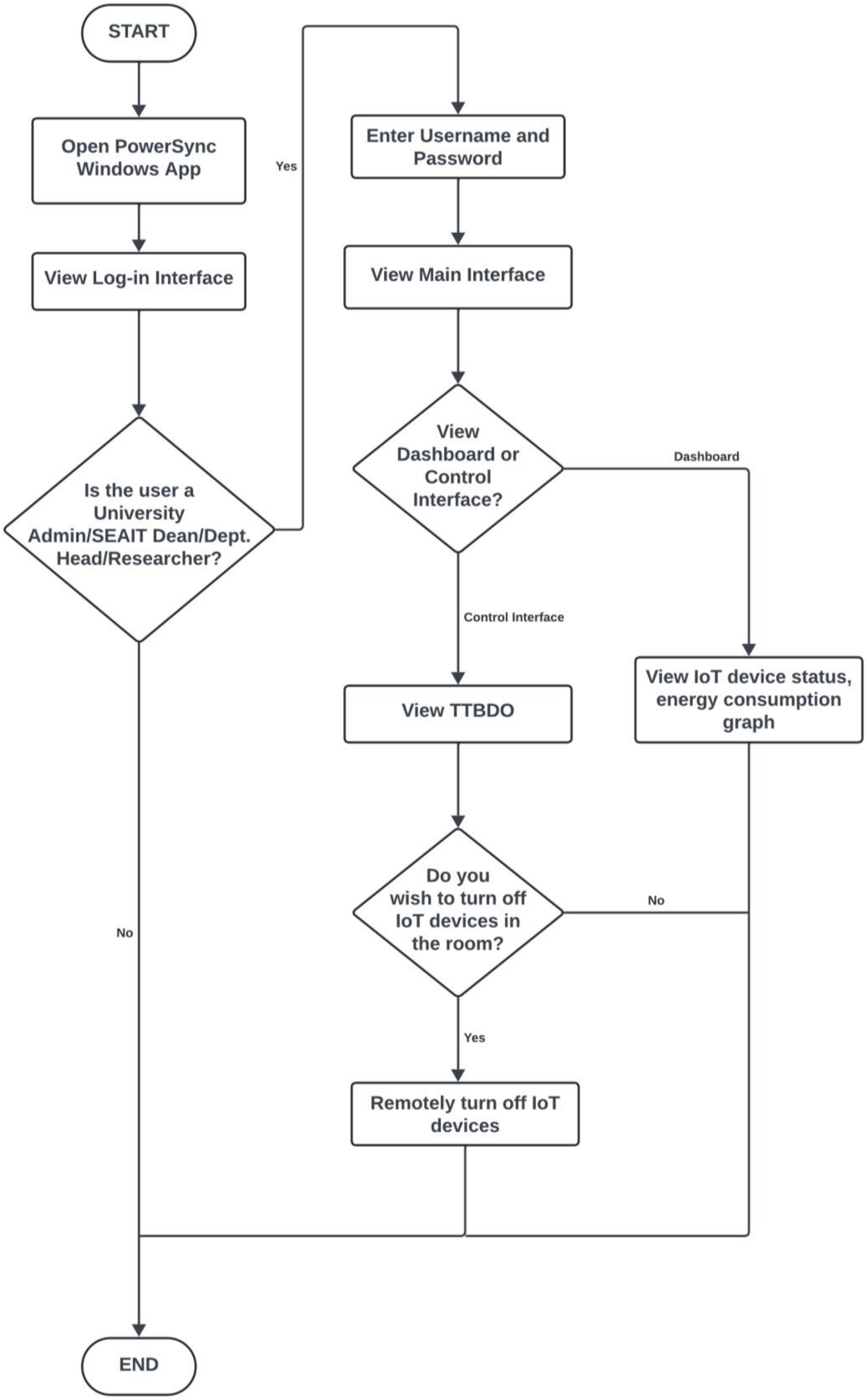


Figure 8
PowerSync Windows App Flowchart



In cases where the users are not registered to access both the website and the software, the user would not be able to bypass the login interface of both the website and the software.

Treatment of Data

The study will employ qualitative methods, specifically online surveys, to evaluate the user-friendliness of PowerSync's user interface. While the system is designed to collect data from Wattcher's sensors, time constraints necessitate the use of Python-generated test data instead as a placeholder for Wattcher. This generated data will be transmitted to a Raspberry Pi server that tracks energy consumption, with all the information stored in a MySQL database.

User feedback regarding the interfaces of both the private website and the Windows application will form the basis for qualitative analysis. Survey results will be used to improve the UI. The website dashboard will visualize data through graphs, providing stakeholders with insights into energy consumption patterns.

Ethical Considerations

The study will be approved by Saint Mary's University Research Ethics Board (UREB), who will be contacted via email or phone. The study adheres to ethical considerations for responsible research practices.

Disclosure of Conflict of Interest. There are no conflicts in conducting this study.

Informed Consent. Twenty-five students were invited to participate in a research study via online survey. The respondent's participation was purely voluntary. Personal information was not collected as it serves no purpose in the study. The purpose of the study is to evaluate the user-friendliness of an energy monitoring system interface and its effectiveness in optimizing energy consumption within a designated area.

Confidentiality and Data Protection. The privacy and confidentiality of data collected through the online survey and the energy monitoring system are kept within secure storage on the Raspberry Pi server, and encryption measures are in place to protect sensitive information. No personal data of the respondents are to be collected in the distribution of online surveys. Additionally, the study emphasizes transparency in the use of collected data, ensuring the user-friendliness of the system interface and that it is only employed for the intended purpose of optimizing energy monitoring and consumption within the designated area. Data gathered will be used until the second semester of the school year 2024-2025, after which it will be disposed of to prevent data leakage.

Conflict of Interest. There won't be any personal gain from the researchers from the study that could compromise the objectives of the study.

Terms of reference. The study will be submitted and owned by Saint Mary's University, but the researchers shall continue to be its authors.

Dissemination Plan. The researchers are targeting to present the results of the study, in collaboration with the ECE research study of Wattcher: An Electrical Energy Monitoring System with LAN Connectivity, to offer a solution for the institute's energy consumption. It will also be presented to different researchers as references for future development and studies.

CHAPTER III

DATA AND RESULTS

This chapter contains the results and insights gained during the development of the Windows App and website, as well as the survey results. It also describes the prototype development of the Windows App and website. The prototype also consists of a miniature scale model of the TTBDO mounted on a plywood board.

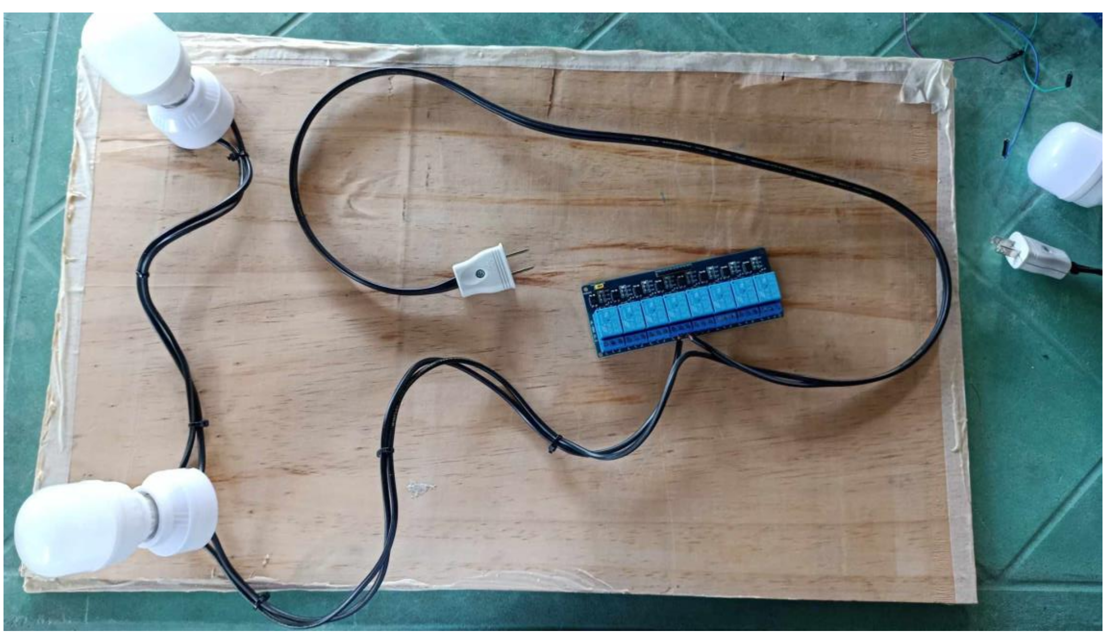
Hardware Development

Programming Arduino UNO R3 paired with Wiznet 5100 using Arduino IDE v2.3.4

The instructions for programming the Arduino UNO and Wiznet 5100 are as follows:

1. Download and install Arduino IDE v2.3.4.
2. Open the software.
3. Create a functional program for the Arduino UNO.
4. Place the Wiznet 5100 on top of the Arduino UNO and connect an ethernet cable to the Wi-Fi Router.
5. Connect the designated pins of the Arduino UNO, Wiznet 5100, and the 8-Channel Relay Board based on the encoded program.

Figure 9
LED connection to relay board



6. Use a Type B cable connector to ensure that the Arduino UNO is plugged into the PC. Select the "Arduino UNO" from the "Tools" menu.
7. Click "Compile" to verify if the code is free from errors.
8. Click "Upload" to load the program onto the Arduino UNO.

Figure 10
Hardware components to scale model

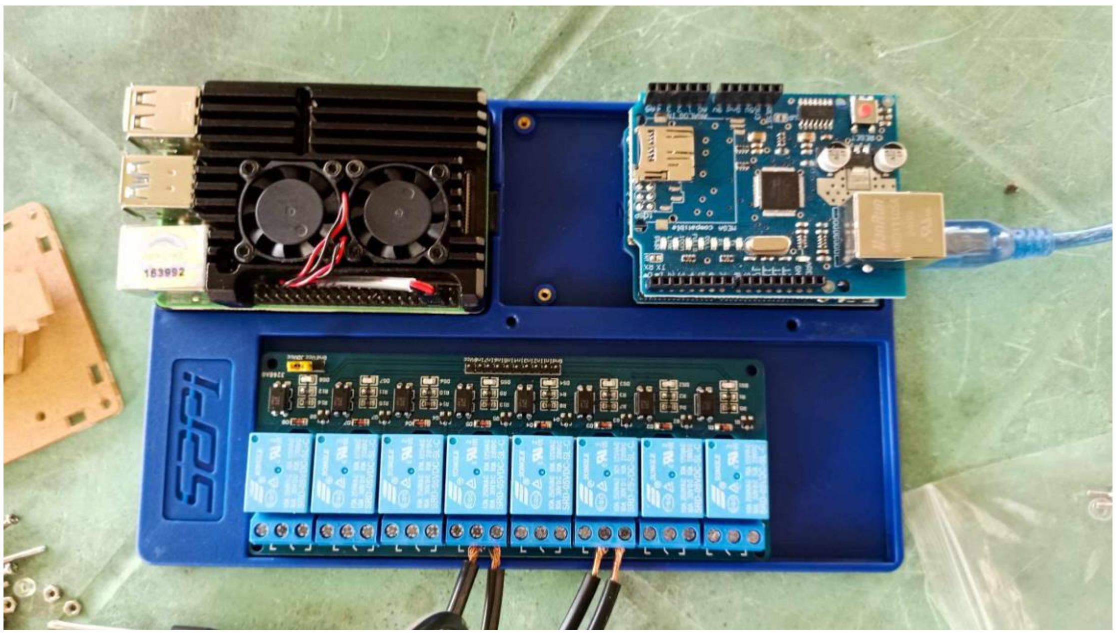


Figure 11
Class for connection

```
using System;
using System.Collections.Generic;
using System.Linq;
using System.Text;
using System.Threading.Tasks;
using MySqlConnector;

namespace Graphs.Connection
{
    2 references
    public abstract class DbConnection
    {
        private readonly string connectionString;
        0 references
        public DbConnection()
        {
            connectionString = "Server =[redacted]; Database =[redacted]; User Id =[redacted]; Password =[redacted]";
        }
        1 reference
        protected MySqlConnection GetConnection()
        {
            return new MySqlConnection(connectionString);
        }
    }
}
```

Figure 12

Request Range for Graph Data

```
// Get request type
$request = $_GET['request'] ?? '';
$range = $_GET['range'] ?? '';
$validCircuitBreakers = ['1', '2', '3']; // Define valid circuit breaker IDs
$circuitBreaker = in_array(needle: $_GET['circuitbreaker'] ?? '1', haystack: $validCircuitBreakers)
    ? ($_GET['circuitbreaker'] ?? '1')
    : '1';

$table = "CircuitBreaker" . $circuitBreaker;

switch ($request) {
    case 'consumption_data':
        // Determine time interval based on range
        $timeInterval = $range === '24h' ? '24 HOUR' : '7 DAY';


        if ($range === '24h') {
         $stmt = $pdo->prepare(query: "
            SELECT
                DATE_FORMAT(Recorded_At, '%H:00') as hour,
                AVG(Voltage) as voltage,
                AVG(Current_A) as current,
                AVG(power) as power,
                SUM(energy) as energy,
                MAX(CASE WHEN HOUR(Recorded_At) BETWEEN 13 AND 16 THEN 1 ELSE 0 END) as is_peak
            FROM $table
            WHERE Recorded_At >= NOW() - INTERVAL 24 HOUR
            GROUP BY hour
            ORDER BY Recorded_At ASC
         ");
```

Setting Up the Raspberry Pi 4 and its Software Components

These are instructions to set up the Raspberry Pi 4:

1. Preparing the operating system:
    - 1.1 Start by mounting the micro-SD card to the computer.
    - 1.2 Download Raspberry Pi OS 64-bit from the webpage.
    - 1.3 Download Raspberry Pi Imager (tool to flash the OS on the microSD).
    - 1.4 Choose the device and board that will be used when the installation of the Raspberry Pi Imager is complete.
    - 1.5 Choose OS and use 64 bits.
    - 1.6 Choose the storage location on the micro-SD card.
    - 1.7 Edit the initial settings setup of the Raspberry Pi OS.
    - 1.8 Set the hostname, username, and password for the Raspberry Pi.
    - 1.9 Connect the Raspberry Pi to the LAN connection.

1.10 Enable SSH (Secure Shell) under the services tab.

1.11 Apply custom settings.

1.12 Flash the OS to a microSD card.

1.13 Connect the Raspberry Pi through SSH.

2. Installing LAMP Server

2.1 Install Apache Web server, run bash script sudo apt, and install apache2-y.

2.2 Install MySQL Database Server, run bash script sudo apt, and install php-y.

2.3 Install PhpMyAdmin, run bash script sudo apt, and install MariaDB-server php-mysql-y.

2.4 Test LAMP Stack and run the IP Address of the Raspberry Pi on a browser.

Figure 13

Fetch data from MySQL query statements

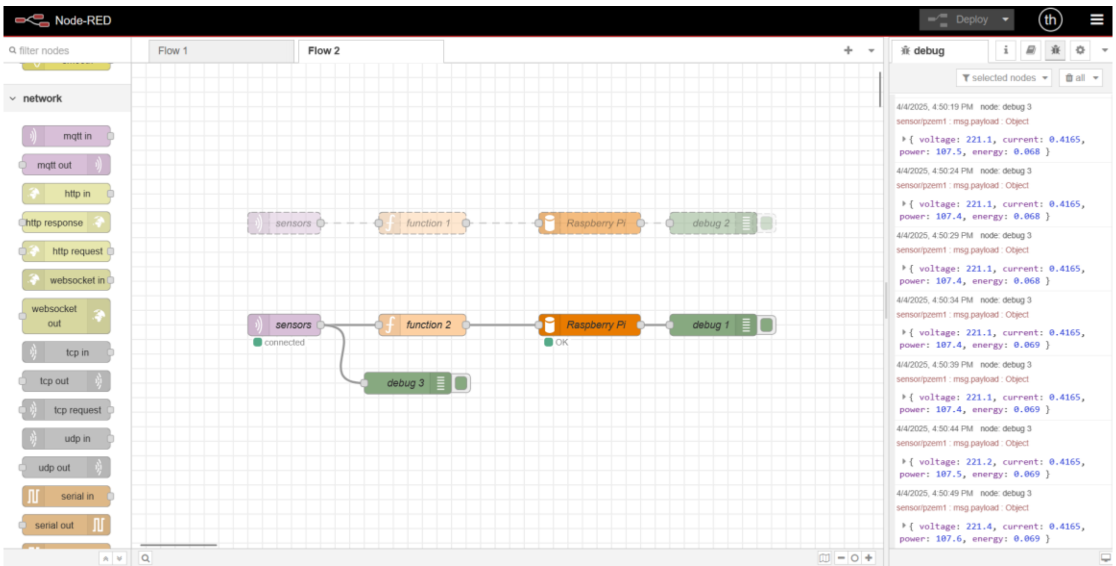
```
    if ($range === '24h') {
     $stmt = $pdo->prepare(query: "
         SELECT
             DATE_FORMAT(Recorded_At, '%H:00') as hour,
             AVG(Voltage) as voltage,
             AVG(Current_A) as current,
             AVG(power) as power,
             SUM(energy) as energy,
             MAX(CASE WHEN HOUR(Recorded_At) BETWEEN 13 AND 16 THEN 1 ELSE 0 END) as is_peak
         FROM $table
         WHERE Recorded_At >= NOW() - INTERVAL 24 HOUR
         GROUP BY hour
         ORDER BY Recorded_At ASC
     ");
 } else if ($range === '7d') {
     $stmt = $pdo->prepare(query: "
         SELECT
             DATE_FORMAT(Recorded_At, '%Y-%m-%d') as date,
             DATE_FORMAT(Recorded_At, '%a') as day,
             AVG(Voltage) as voltage,
             AVG(Current_A) as current,
             AVG(power) as power,
             SUM(energy) as energy,
             MAX(CASE WHEN HOUR(Recorded_At) BETWEEN 13 AND 16 THEN 1 ELSE 0 END) as is_peak
         FROM $table
         WHERE
         Recorded_At >= DATE_SUB(CURRENT_DATE(), INTERVAL 6 DAY)  -- Last 7 days (including today)
         AND Recorded_At < CURRENT_DATE() + INTERVAL 1 DAY       -- Ensure we include today
         GROUP BY date
         ORDER BY Recorded_At ASC
     ");
 }

    $stmt->execute();
```

3. Installing Mosquitto MQTT Broker

4. Installing Node-RED

Figure 14
Deployed Node- RED Flow Diagram



Creating the miniature model of the TTBDO

1. Connect dedicated pins to the relay module to the Arduino board.
2. Connect the LED Bulbs to the relay board (Refer to Figure 9).
3. Place the hardware components on a tabletop scale model (Refer to Figure 10).

Figure 15
Detecting the Raspberry Pi within the router

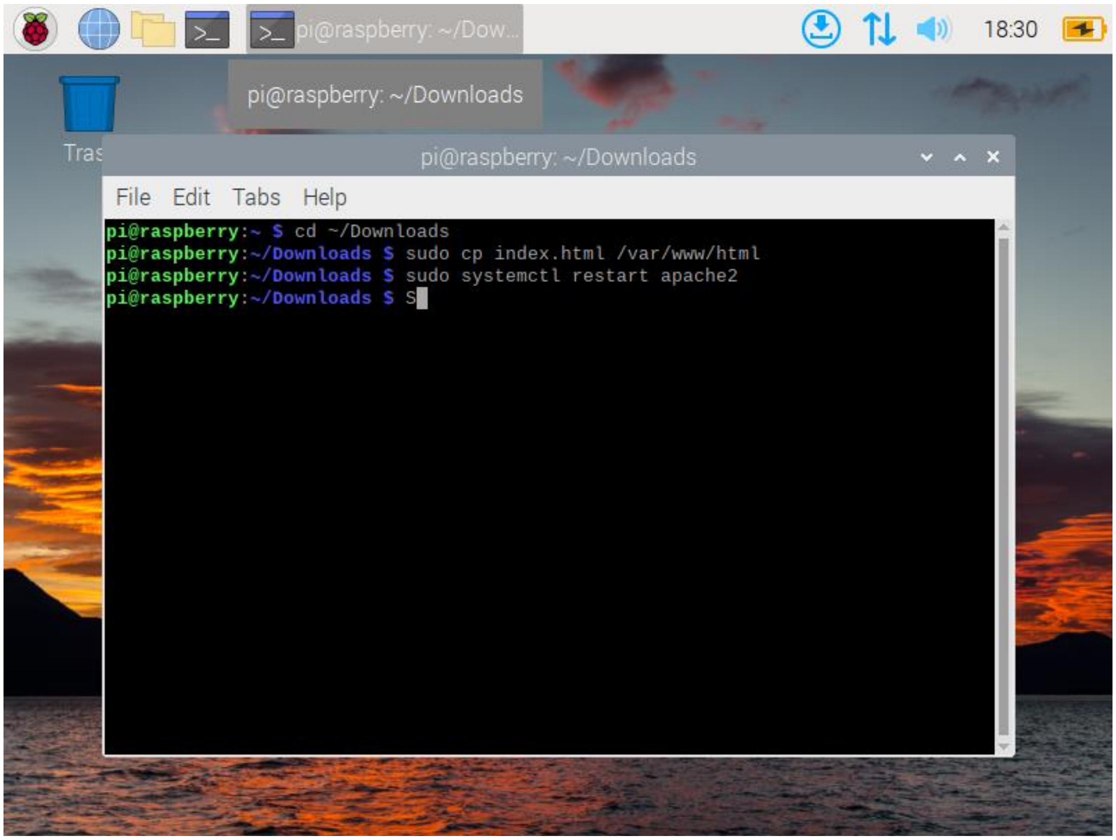
DHCP Clients List

This page displays information of all DHCP clients on the network.

ID	Client Name	MAC Address	Assigned IP	Lease Time
1	LAPTOP-DD11BKLU	50:FE:0C:02:F7:77	192.168.0.100	00:00:43
2	raspberrypi	D8:3A:DD:E8:83:50	192.168.0.101	00:00:59

Refresh

Figure 16
Raspberry Pi Terminal



Software Development

Designing Windows App using Visual Studio 2022

1. Download and install Visual Studio.
2. Click "Create a new project" and select the template Windows Forms App (.NET Framework)
3. Input the Project name and modify the project's folder location based on your preference, then click "Create."
4. Install the following solutions: MySQL.Data and MySQLConnector can be done by clicking on Tools>NuGet package manager>Manage packages for solutions. Select the project to which these solutions would be applied and click Install.
5. Design and program the functionalities of the application.
6. To connect the application to the server, create a class and refer to Figure 11 to establish a TCP/IP connection.

7. To publish the application, download the extension Microsoft Visual Studio Installer Projects 2022 by clicking Extensions and clicking Extension Manager. Click on the project solution and add a setup project.
8. To publish the application, download the extension Microsoft Visual Studio Installer Projects 2022 by clicking Extensions and clicking Extension Manager. Click on the project solution and add a setup project.
9. Right-click on the Setup project and specify the location on where to publish the application, then click Build.

Figure 17
Python Script for simulated data

```python
import random
import mysql.connector
from datetime import datetime, timedelta

# Database connection
db = mysql.connector.connect(
    host="localhost", #different on raspberrypi
    port="3307",
    user="root",
    password="",
    database="pwrsync"
)
cursor = db.cursor()

# Start time
start_time = datetime(2025, 4, 1, 0, 0, 0)
voltage = 220
time_interval = 30
num_records = (7*24*60*60) // time_interval

# Generate and insert data
for i in range(num_records):  # 1440 records
    recorded_at = start_time + timedelta(seconds=time_interval * i)
    voltage;
    current = 40.0 + random.uniform(-40, 10)
    time_interval_hours = time_interval / 3600
    power = voltage * current
    energy = power * time_interval_hours
    query = f"INSERT INTO circuitbreaker1 (Voltage, Current_A, Power, Energy, Recorded_At) VALUES ({voltage}, {current}, {power}, {energy}, '{recorded_at}')"
    cursor.execute(query)

# Commit and close
db.commit()
cursor.close()
db.close()

print("generation completed")
```

Designing Website using Tailwind C++ Libraries

1. Download and install Visual Studio Code.
2. On the welcome page, click "new file" and enter the file name using the format .html.
3. Place the file in the preferred folder.
4. Create a new file for the script with the file format being .js and place it in the same folder as the index and styles.

5. Create another file for the data fetcher with the file format being .php and put it in the same folder as before.
6. Use the code from Figure 12 to request data from the database from 7 days to 24 hours.
7. Use the code from Figure 13 to fetch data from the MySQL query statements to prepare data and send it to the website.

Figure 18
Python Script for posting batch data

```python
import random
import mysql.connector
from datetime import datetime, timedelta
import time

def connect_to_database():
    try:
        db = mysql.connector.connect(
            host="localhost",
            port="3307",
            user="root",
            password="",
            database="pwrsync"
        )
        return db
    except mysql.connector.Error as err:
        print(f"Database connection error: {err}")
        return None

def generate_sensor_data(db):
    voltage = 220
    time_interval = 30  # seconds

    while True:
        try:
            cursor = db.cursor()
            recorded_at = datetime.now()
            current = 40.0 + random.uniform(-40, 10)
            time_interval_hours = time_interval / 3600
            power = voltage * current
            energy = power * time_interval_hours

            query = """
            INSERT INTO CircuitBreaker1
            (Voltage, Current_A, Power, Energy, Recorded_At)
            VALUES (%s, %s, %s, %s, %s)
            """
            values = (voltage, current, power, energy, recorded_at)
```

Figure 19

Generated Data Insertion

```
Starting sensor data generation...
Data inserted at 2025-05-14 08:32:13.191731: Voltage=220V, Current=14.70A, Power=3234.97W, Energy=26.958052kWh
Data inserted at 2025-05-14 08:32:43.196123: Voltage=220V, Current=47.95A, Power=10550.08W, Energy=87.917364kWh
```

Establishing Raspberry Pi 4 as the server

1. Use Node-RED script to establish a connection for the sensor to a database connection (Refer to Figure 14).
2. Determine if the router can detect the Raspberry Pi (Refer to Figure 15).
3. Input the Linux commands through the Raspberry Pi terminal; this is where most of the applications and APIs to be hosted on the Raspberry Pi are installed (Refer to Figure 16).
4. Create the database using phpMyAdmin.

Python Generated Data

1. Figure 17 displays the Python code script that simulates real-time data collection by posting measurements directly to the database.
2. For historical data simulation, consult Figure 18, which shows the process for importing batch data from specified date ranges to populate the database.
3. Figure 19 illustrates the successful insertion of generated data into the database, including the confirmation message and record count.
4. As shown in Figure 20, the successfully generated data has been stored in the database, where you can verify the complete record structure with all associated fields populated.

Figure 20

Generated data is stored in the database

←T→			DataID	Voltage	Current_A	Power	Energy	Recorded_At ▲ 1
Edit	Copy	Delete	1	220	25.138264160254213	5530.418115255927	46.086817627132724	2025-04-01 00:00:00
Edit	Copy	Delete	2	220	49.297601421755886	10845.472312786294	90.37893593988579	2025-04-01 00:00:30
Edit	Copy	Delete	3	220	12.05379737112957	2651.8354216485054	22.098628513737545	2025-04-01 00:01:00
Edit	Copy	Delete	4	220	33.22932011146866	7310.4504245231055	60.92042020435921	2025-04-01 00:01:30
Edit	Copy	Delete	5	220	0.19646246678960466	43.221742693713026	0.3601811891142752	2025-04-01 00:02:00
Edit	Copy	Delete	6	220	44.736023513049155	9841.925172870813	82.01604310725678	2025-04-01 00:02:30
Edit	Copy	Delete	7	220	44.79781009699483	9855.518221338863	82.1293185111572	2025-04-01 00:03:00
Edit	Copy	Delete	8	220	27.084656862818484	5958.624509820066	49.65520424850055	2025-04-01 00:03:30
Edit	Copy	Delete	9	220	30.80912253487078	6778.006957671571	56.48339131392976	2025-04-01 00:04:00
Edit	Copy	Delete	10	220	11.293348625542706	2484.5366976193955	20.704472480161627	2025-04-01 00:04:30
Edit	Copy	Delete	11	220	16.792349833252512	3694.3169633155526	30.78597469429627	2025-04-01 00:05:00

System Functionalities

PowerSync Windows App (Monitoring and Control Side)

Figure 21

Login Page

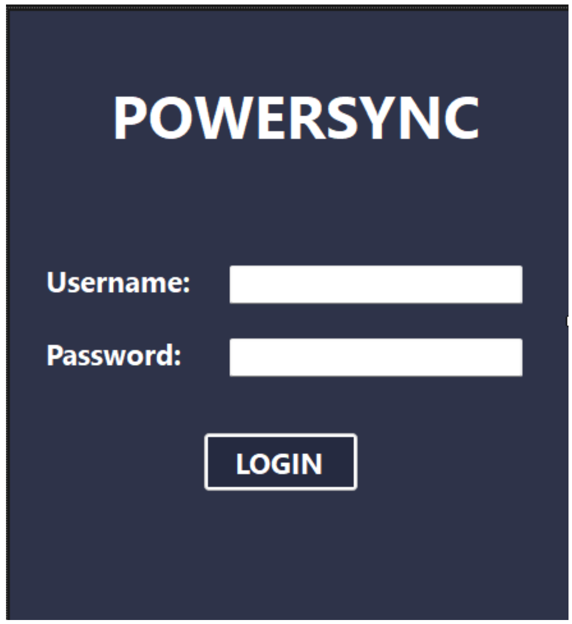
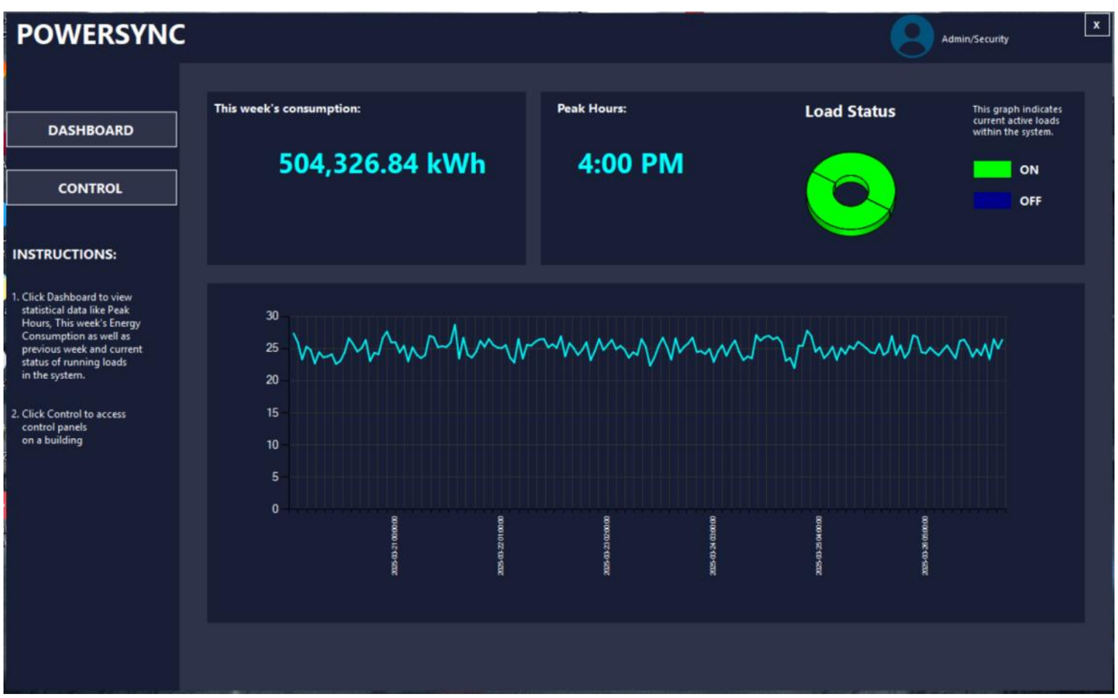


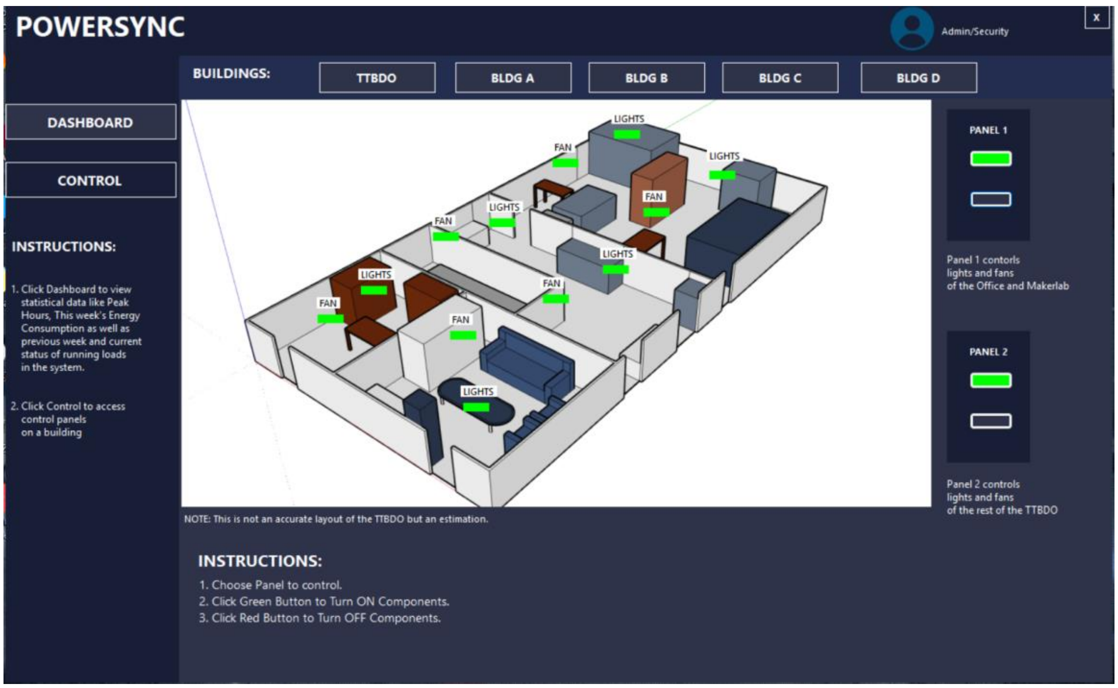
Figure 22

Dashboard



The login page for the Windows app platform (Refer to Figure 21). University administration and security guards are required to enter the username and password provided by the researchers. If inputs are incorrect, an "Invalid Login: username or password is incorrect" message will appear. This ensures that only authorized users are able to gain access to the system.

Figure 23
Control Page



The main dashboard provides the user with the system's status, containing power consumption within the current week of last week, as well as peak hours and current active loads. It also displays statistical graphs that display consumption within a certain time range. On the left side, users can find the navigation bar. By default, the dashboard page is on display. Clicking on the Control button takes the user to the control page, where the user can monitor and control electrical loads within the TTBDO (Refer to Figure 22).

On the control page, the user is given access to view the TTBDO, which is the main site focus of the study. By clicking the TTBDO button, users can access the simple layout of the TTBDO. BLDG A, B, C, and D are only accessible for viewing and are for future development. The TTBDO control panel allows the user to view and control active and inactive electrical loads within the building. There are two panels: Panel 1 controls the Office and Makerlab, and Panel 2 controls the Laboratory. The users can control the electrical loads by clicking on the green button to turn "ON" and the red button to turn "OFF" in each panel (Refer to Figure 23). Control panels in Figure 24 are only for the future scalability of the system. Users will also be able to add floors per building and control them by clicking on the green and red buttons to turn "ON" and "OFF" loads, respectively.

Figure 24

Bldg. A, B, C, D Control Panel

PowerSync Website (Statistics)

The login page for the website just like in the Windows app platform; users (University Administration, SEAIT Dean, and Department Heads), as well as the Admin (Researchers), are required to enter their username and password provided by the researchers. If the inputs are incorrect, a red message that says "Invalid username or password" will appear. This also ensures that, just like in the Windows app platform, only authorized users can gain access to and use the system (Refer to Figure 25).

After logging in, the main dashboard of the website provides the Admin with the average current that is consumed. This peak time indicates the time when power consumption is at its peak and the system's status. It also shows a line graph of the energy used and the peak hours of power consumption within the last 24 hours (Figure 26) and the last 7 days (Figure 27), which can be selected in the drop-down selector. On the top right, it also shows that the admin user is logged in. The main dashboard also has the statistics page, the users page, and the logout button. If the Admin wants to log out, they can click the logout button, and their account will be logged out and go back to the login page.

The main dashboard for the users guards the same as the main dashboard for the admins but with the exclusion of the user's page.

Figure 25
Login Page

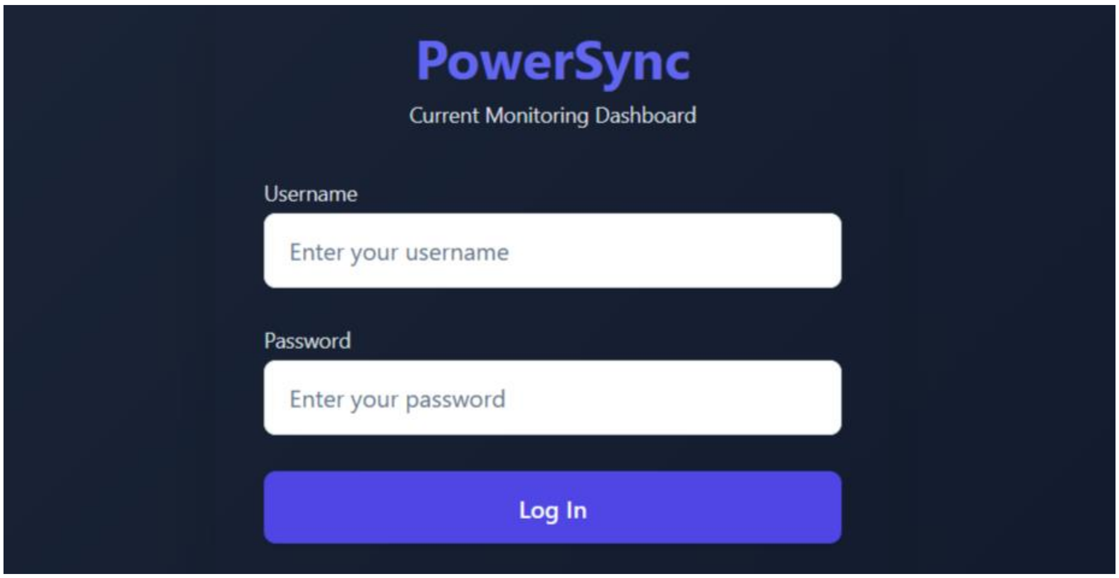


Figure 26
Dashboard for the Admin (Researchers)

Figure 27
7 days data

Figure 28
Dashboard for Users (University Administration, SEAIT Dean and Department Heads)

Figure 29

Statistics Page

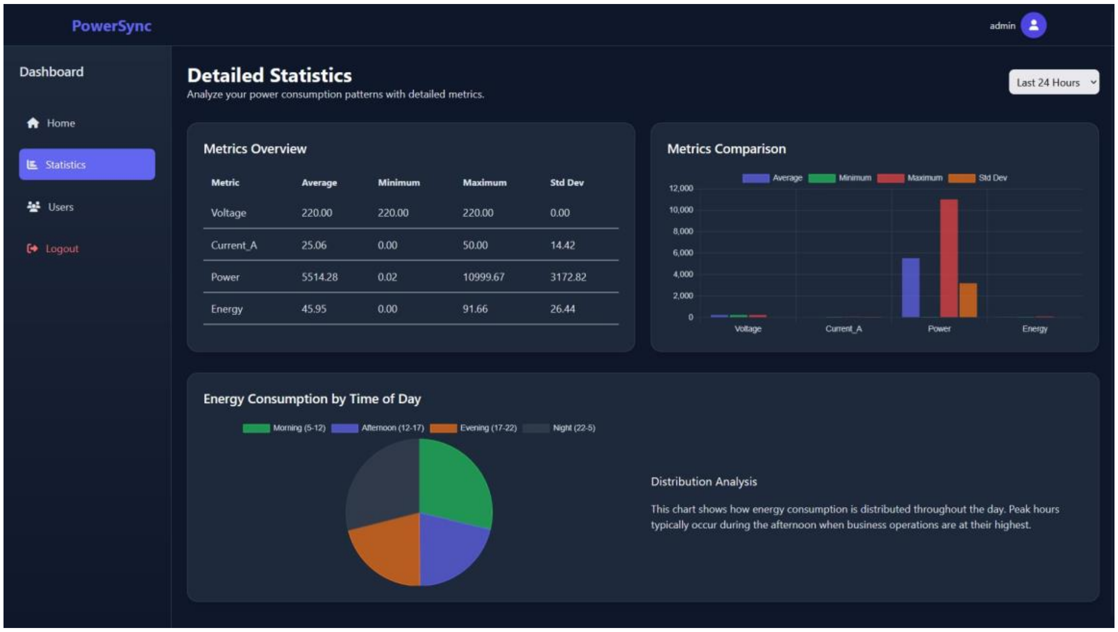
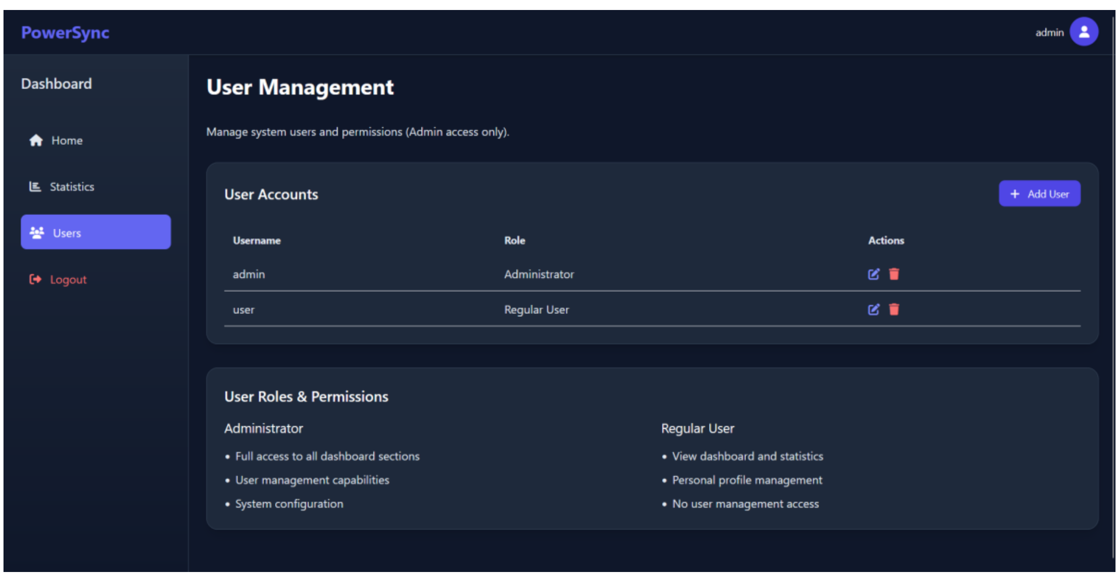


Figure 30

Users Page (Only for Admins)



This page shows the detailed statistics of power consumption. It has a metrics overview that shows the specific values for the average, minimum, maximum, and standard deviation of the voltage and current. The metrics comparison shows a visual bar graph for all the voltage and current, which can all be interacted with. The current consumption by time of day shows a pie chart of how current consumption is distributed throughout the day. Both users and Admin can access the statistics page (Refer to Figure 29).

The user's page can only be accessed and viewed by the Admin. This allows the Admin to manage all the user accounts. The admins are able to add new users and edit or delete current users (Refer to Figure 30).

Interface User-Friendliness Evaluation

Our online usability assessment gathered feedback from 25 participants who evaluated our interfaces based on user-friendliness criteria. The structured evaluation provided valuable insights into the effectiveness of our current design approach. It highlighted specific areas of strength and opportunities for enhancement.

Analysis of the UI satisfaction (Refer to Figure 32) survey reveals compelling results: 68% of users rated the system interface as "Excellent." In comparison, 22.67% considered it "Commendable." Only 8% of respondents assessed the UI as merely "Competent," with a minimal 1.3% finding it "Challenging."

Analysis of the user experience data (Refer to Figure 33) reveals exceptional satisfaction levels, with 69% of respondents awarding the system interface the highest rating of "Excellent." An additional 22% classified the UI as "Commendable," while the remaining 9% evaluated it as "Competent."

Figure 31
Online Survey Results (Windows App)

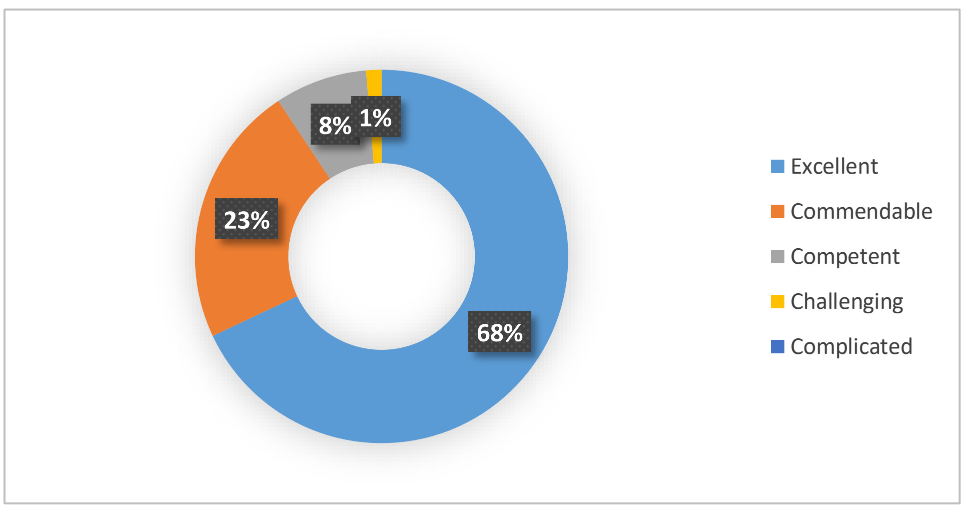
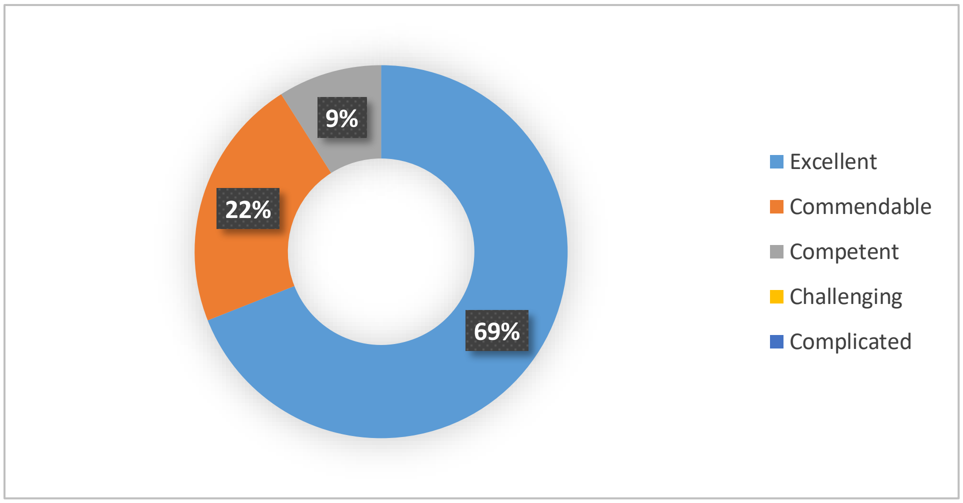


Figure 32
Online Survey Results (Website)



PowerSync's Scalability

Node-RED's Scalability

Node-RED harnesses the full capabilities of Node.js, an event-driven JavaScript runtime engineered for building scalable network applications. As a browser-based visual programming tool, Node-RED enables developers to efficiently manage multiple concurrent connections and complex data streams with minimal overhead. Its non-blocking architecture allows for responsive handling of real-time events across distributed systems. It is particularly well-suited for IoT implementations and enterprise integration scenarios.

The Role of Arduino

The Arduinos primarily act as sensors or actuators and control external devices such as LED lights. It is connected to the Raspberry Pi via protocols like MQTT, which Node-RED can then manage.

Raspberry Pi as the Hub

The Raspberry Pi acts as a central hub, receiving data from the Arduinos, processing it, and sending commands back. The key to scalability lies in how well the Raspberry Pi can handle the volume and complexity of data flowing through it.

Factors Affecting Scalability

1. Network Bandwidth can be a bottleneck if too many Arduinos are sending data simultaneously.

2. Raspberry Pi's Processing Power can be overloaded with processing tasks like analyzing sensor data, and it might struggle to handle the influx of information from many Arduinos.
3. Node-RED Flow Complexity can impact performance as well.

Strategies to Improve Scalability

Data Aggregation and Filtering

Implement strategic data consolidation at the Arduino level to minimize network traffic by aggregating and pre-processing sensor readings before transmission to the Raspberry Pi. This edge-filtering approach reduces bandwidth consumption, decreases central processing load, and extends battery life for wireless implementations by eliminating redundant or insignificant data points.

Asynchronous Processing

Leverage Node-RED's event-driven architecture to process multiple Arduino data streams concurrently without blocking the main execution thread. By implementing non-blocking flows with proper error handling, the system maintains responsiveness even when handling dozens of simultaneous connections, ensuring critical data is processed without introducing latency or resource contention.

Distributed Architecture

Scale to enterprise-level deployments by implementing a hierarchical network of Raspberry Pis, where a primary controller orchestrates communications while secondary Pi nodes manage localized Arduino clusters. This tiered approach enables fault isolation, improves system resilience through redundancy, and allows for geographical distribution while maintaining centralized monitoring and control capabilities.

CHAPTER IV
CONCLUSION AND RECOMMENDATION

Summary

The researchers implemented an Arduino-based and Raspberry Pi server control system that integrates hardware and software to offer statistical data via a private website and monitor and control electrical loads over a LAN connection. The project uses a variety of connected components to carry out all its intended functionalities. The following is a summary of the study.

1. An integration between an Arduino-based and a Raspberry Pi server monitoring and control system can be effectively achieved through an architecture that addresses multiple layers, as demonstrated by researchers who implemented Node-RED flows, MQTT, and direct TCP/IP socket connections.
2. The connection between software controls, Arduino, Raspberry Pi, and associated hardware was successfully established by researchers who transmitted messages and packets using TCP/IP and MQTT protocols, allowing Arduino to be programmed to control the devices used in the study.
3. The system communicates information about the status of electrical components to the users using status messages that indicate component activity in rooms through Node-RED, MQTT, and TCP/IP connections that facilitate real-time communication as the status between software and hardware control. However, researchers used simulated data due to time constraints that prevented full integration with the partnering ECE group's Wattcher study.

Conclusion

Both the website and the Windows app show complete functionality based on the prototype's testing. The effectiveness of the study's goals is demonstrated by the evidence that follows.

1. The project successfully links Arduino and Raspberry Pi communication to the hardware components through a LAN connection utilizing Node-RED and MQTT protocol.
2. The researchers successfully developed a fully operational and scalable monitoring and control system for electrical loads.
3. The system was able to establish a connection with Wattcher. However, due to time constraints, the researchers still opted to use generated data as data readings from Wattcher are not yet available.

4. Data from online surveys indicates remarkable user approval, with more than 90% of respondents evaluating the interface as exceeding typical standards. Notably, no participants provided negative feedback.
5. While a Raspberry Pi can handle a substantial number of Arduinos through Node-RED, the practical limit depends on the specific hardware and software configuration.

Recommendations

The following recommendations are for future researchers and studies aiming to enhance the current prototype. These suggestions are also directed toward the beneficiaries of this study.

1. Enhance UI design and functionality of the Windows App and Local Website.
2. Make more use of the Raspberry Pi instead of only utilizing it as a server.
3. Use ESP32 or ESP8266 rather than Arduino UNO and Wiznet 5100 since it is more cost-effective and does twice the same job with just one component rather than two.
4. Improve the scalability of the project by giving access to monitor and control more buildings, such as cloud systems, to improve system control response.
5. Implement a timer indicator that displays the remaining time until electrical loads are remotely turned off in a room.
6. Assigning one Raspberry Pi per building appears to be the most practical approach, given the number of connections managed by the microcontroller.

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Appendix A Student Researcher's Letter of Intent for Prospective Adviser-Promoter

SAINT MARY'S UNIVERSITY
BAYOMBONG, NUEVA VIZCAYA, PHILIPPINES
UNIVERSITY RESEARCH CENTER

Document Code	URC-FO-010
Revision	02
Effectivity Date	2022/11/17
Page/s	Page 1 of 1

**STUDENT-RESEARCHERS' LETTER OF INTENT
FOR PROSPECTIVE ADVISER-PROMOTER**

Date: 09-27-2024

ENGR. CARINA S. MALLILLIN
Officer-In-Charge, Office of the Dean
School of Engineering, Architecture and information Technology

Dear Madam:

We, the undersigned, wish to avail of the services of Kenasis John B. Wajchina as adviser to our research paper entitled **EMCS: Energy Monitoring and Control System.**

We promise to work closely with our adviser-promoter in the accomplishment of our project and to comply with the deadlines set by him / her, as well as make ourselves available for consultation to facilitate the research process.

Proponents (*Names and Signatures*):

RIVERA, Gabrielle C.
DUGAY, Euder Wayne P.
TADEO, Lloyd Vince Angelo B.

CARINA S. MALLILLIN
9/27/24

Recommending Approval:

Research Instructor
(Signature over Printed Name)

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Second Floor, Rev. John Van Bauwel Building
SMU Main Campus, Ponce Street,
Bayombong, 3700 Nueva Vizcaya, Philippines
smu.edu.ph / stmarysuniversityresearch@gmail.com

Appendix B Adviser-Promoter Acceptance Form

SAINT MARY'S UNIVERSITY
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Revision	02
Effectivity Date	2022/11/17
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ADVISER-PROMOTER ACCEPTANCE FORM

Date: 09-26-2024

☑ I hereby accept the proponent/s:

1. RIVERA, Gabrielle C.
2. DUGAY, Euder Wayne P.
3. TADEO, Lloyd Vince Angelo B.
4.
5.

as research advisee/s for the study,

EMCS: Energy Monitoring and Control System

for the School Year 2024-2025.

I promise to abide by my duties and responsibilities and ascertain that my advisees finish their research output on schedule and according to the rules set by the University Research and Community Development Council.

Conforme:

KENOSIS JOHN B WAJCHINA
Printed Name and Signature of Prospective Adviser-promoter

☐ I cannot accept the above thesis advisership due to the following reasons:

Printed Name and Signature of Requested Adviser-promoter

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Appendix C Agreement on Promotership

SAINT MARY'S UNIVERSITY
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Revision	02
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AGREEMENT ON PROMOTERSHIP

Date: 09-26-2024

This agreement is made between:

KENOSIS JOHN B. WAJCHINA
(Name of Adviser-Promoter /Signature over Printed Name)

As the promoter, I agree to dispense the duties and responsibilities as indicated:

1. Aid the research team conceptualize and develop a research problem based on Research Agenda and check its progress;
2. Write initial inputs on appropriate research design and techniques and assist the team to craft or adapt appropriate tool(s);
3. Assist the research team in preparing for the defenses and tutor them on how to make good in their presentations;
4. Check the integration of suggestions made by the technical panel and guide the research teams in the enrichment of the manuscript;
5. Advise the research team for the ethical review of the proposal manuscript and direct them in the integration of comments;
6. Suggest helpful methods and/or techniques in the collection of data;
7. Conduct blended mentoring sessions with advisees from conceptualization to submission;
8. Attend to the inquiries of the research team for further development of the manuscript;
9. Monitor the performance of the research team from the write-up to the conduct of the research;
10. Aid the research teams in presenting, analyzing and interpreting data; and
11. Make initial editing and proofreading works from proposal to full paper.

and

(Students' names and signatures)

RIVERA, GABRIELLE C.
DUGAY, EUDER WAYNE P.
TADEO, LLOYD VINCE ANGELO B.

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As researchers, we agree to conduct the research project under the supervision of our adviser-promoter; and expected to:

a) Write the topic proposal under the supervision of our adviser-promoter;
b) Report to our adviser-promoter on a regular basis to guarantee development of the manuscript;
c) Perform research tasks assigned by our adviser-promoter;
d) Follow the technical writing aspects of the paper;
e) Present proposal paper (during Research 1) and defend the final thesis (in Research 2) through the guidance of our adviser-promoter;
f) Integrate comments and suggestions made by the technical panel of evaluators and by the UREB reviewers;
g) Do data gathering and initial coding of data in excel format through the assistance of our adviser-promoter;
h) Write the full manuscript;
i) Disseminate research results in a forum; and
j) Submit required outputs (Bound full manuscript, IMRAD publishable format & CDs).

We do hereby abide and affix our signatures with the above-mentioned duties and responsibilities for the success of this research endeavor.

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Appendix D Certificate of Approval

SAINT MARY'S UNIVERSITY
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UNIVERSITY RESEARCH ETHICS OFFICE

Document Code	EOMS-REO-RF-015, Rev 00
Effectivity Date	2024/12/08
Page/s	1 of 1

CERTIFICATE OF APPROVAL

This certifies that the following protocol and related documents have been reviewed and approved by SMUREB for implementation.

SMUREB Code: 2025 0823

Research Proponent: GABRIELLE C. RIVERA
EUDER WAYNE P. DUGAY
LLOYD VINCE ANGELO B. TADEO
KENOSIS JOHN B. WAJCHINA, RCpE, (Adviser-Promoter)

Title: Powersync: Optimizing Energy Monitoring Through Arduino and Raspberry PI Server Based Control System

Protocol Version No.:	1	**Version Date:**	January 8, 2025
ICF Version No.:	N/A	**Version Date:**	N/A
Type of Review:	Exempted	**Validity:**	12 months

Responsibilities of the research proponent after approval:

1. Apply for a review of amendments (REO-FO-010) as soon as there are changes in the protocol.
2. Submit a report of any deviations/violations of the protocol or data-gathering procedure (REO-FO-012) within 2 weeks after detecting the deviation/violation.
3. Submit report of any negative events affecting the integrity of the data-gathering procedure from participants (REO-FO-013) within 2 weeks after detecting the negative events.
4. Apply for continuing review (REO-FO-014) if the research project is not completed within the validity period of this certificate of approval.
5. Submit an early termination report (REO-FO-016) if the research project is discontinued.
6. Submit the final report (REO-FO-017) after completion of the research project. *This is mandatory*. The research proponent will be given a final ethics clearance certificate.

This certificate of approval is valid until January 14, 2026

Issued and signed on January 15, 2025.

JASON ARNOLD L. MASLANG
Chair, SMUREB

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Appendix E Plagiarism Certification

SAINT MARY'S UNIVERSITY
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Document Code	EOMS-URC-FO-024, Rev. 00
Effectivity Date	2024/12/09
Page/s	Page 1 of 1

PLAGIARISM CERTIFICATION

Research Proponents:
Dugay, Euder Wayne
Rivera, Gabrielle
Tadeo, Lloyd Vince Angelo

Adviser-Promoter:
Kenosis Wajchina

Program:
Bachelor of Science in Computer Engineering

This is to certify that the research paper entitled:
POWERSYNC: Optimizing Energy Monitoring through Arduino and Raspberry PI Server Based Control System

has undergone the initial plagiarism check with an originality score / grade of 95%.

☐ This signifies that the manuscript failed the minimum threshold, and hence, cannot proceed to final defense.

☑ This signifies that the researchers may proceed to final defense and that the official plagiarism clearance will be issued as soon as the integration of final suggestions by the panel is complied with.

ENGR. MICHELLE KYRA S. BAUTISTA
Evaluator

APRIL 07, 2025
Date

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Appendix F Plagiarism Clearance

SAINT MARY'S UNIVERSITY
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Document Code	EOMS-URC-FO-027, Rev. 00
Effectivity Date	2024/12/08
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PLAGIARISM CLEARANCE

Research Proponents:
Dugay, Euder Wayne
Rivera, Gabrielle
Tadeo, Lloyd Vince Angelo

Adviser-Promoter:
Engr. Kenosis Wajchina

Program:
Bachelor of Science in Computer Engineering

Research Title:
POWERSYNC: Optimizing Energy Monitoring through Arduino and Raspberry PI Server Based Control System

This is to certify that the above research manuscript passed the plagiarism evaluation and is ready for grammar and organization and APA format and style compliance evaluations.

ENGR. MICHELLE KYRA S. BAUTISTA
Evaluator

MAY 23, 2025
Date

Note: *Result 96%*

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Appendix G Ethical Clearance Certificate

SAINT MARY'S UNIVERSITY
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UNIVERSITY RESEARCH ETHICS OFFICE

Document Code	EOMS-REO-FO-078, Rev 00
Effectivity Date	2024/12/08
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ETHICAL CLEARANCE CERTIFICATE

This certifies that the following protocol and related documents have been approved, monitored, and granted clearance by SMUREB.

SMUREB Code: 2025 0823
Research Proponent/s: GABRIELLE C. RIVERA
EUDER WAYNE P. DUGAY
LLOYD VINCE ANGELO B. TADEO
KENOSIS JOHN B. WAJCHINA, RCpE, (Adviser-Promoter)
Title: Powersync: Optimizing Energy Monitoring Through Arduino and Raspberry PI Server Based Control System

Protocol Version No.: 1
Version Date: January 8, 2025
ICF Version No.: N/A
Version Date: N/A
Type of Review: Exempted

The research proponent has submitted the final report form and has complied with all the requirements of the Research Ethics Board.

Issued and signed on May 22, 2025.

JASON ARNOLD L. MASLANG
Chair, SMUREB

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Appendix H Language Editing Clearance

Document Code	EOMS-URC-FO-028, Rev. 00
Effectivity Date	2024/12/08
Page/s	Page 1 of 1

Language Editing Clearance

Research Proponent:
Dugay, Euder Wayne
Rivera, Gabrielle
Tadeo, Lloyd Vince Angelo

Adviser-Promoter
Engr. Kenosis Wajchina

Program:
Bachelor of Science in Computer Engineering

Research Title:
POWERSYNC: Optimizing Energy Monitoring through Arduino and Raspberry PI Server Based Control System

Date of Final Defense:
April 11, 2025

This is to certify that I have thoroughly edited the final draft of the Research of the student/s listed above in terms of grammar and organization.

DR. HAYDEE D. JAMES — **MAY 27, 2025**
Editor — ***Date***

This is to certify that I have thoroughly edited the final draft of the Research of the student/s listed above for compliance with the APA Format and Style.

DR. HAYDEE D. JAMES — **MAY 27, 2025**
Editor — ***Date***

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Appendix I Certificate/ Declaration of Originality

SAINT MARY'S UNIVERSITY
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Certificate / Declaration of Originality

Research Proponents:
Euder Wayne P. Dugay
Gabriell C. Rivera
Lloyd Vince Angelo B. Tadeo

Adviser-Promoter:
Engr. Kenosis John B. Wajchina

Program:
Computer Engineering

Research Title:
PowerSync: Optimizing Energy Monitoring through Arduino and Raspberry Pi Server-Based Control System

---

We hereby submit our research paper and truthfully declare that the manuscript is a product of our original research investigation. To the best of our knowledge and belief, it contains no material previously published or written by another person or group nor does it include contents that are falsified or fabricated. We also sought the University Research Center for a preliminary and final reading of the paper to seek for Plagiarism Clearance.

We understand that should Saint Mary's University represented by its Administrators and Faculty eventually discover that our testimonies herein are not so, we accept the right of the University to impose appropriate sanctions due us.

Signed at Saint Mary's University on: June 02, 2025, 12:30pm (Complete Date & Time).

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Document Code	EOMS-URC-FO-029, Rev. 00
Effectivity Date	2024/12/08
Page/s	Page 2 of 2

Research Team	Complete Name	Signature	Date of Final Plagiarism Check (Rating)
Adviser-Promoter	Engr. Kenosis John B. Wajchina		May 23, 2025 4%
Student-Researchers	Euder Wayne P. Dugay		
	Gabrielle C. Rivera		
	Lloyd Vince Angelo B. Tadeo		

SUBSCRIBED AND SWORN TO before this 02 JUN 2025 at Solano, Nueva Vizcaya by the aboved-named affiant(s) who was/were identified through his/her/their competent proof of identify.

Doc. No. 101;
Page No. 22;
Book No. III;
Series of 2025.

ATTY. ANGEL ANNINA GAIL J. UY
PTR No. 2970878 / 01-02-2025
IBP No. 494887; 01-02-2025
Roll of Attorneys No. 87742
Pob. North, Solano, Nueva Vizcaya
Notarial Commission No. 35-23
Commissioned until 31 December 2025
MCLE Compliance No. VIII-0009995

Appendix J Informed Consent Form

Informed Consent Form

Research Title: PowerSync: An Integrated Arduino and Raspberry Pi Energy Monitoring and Control System

Principal Investigators:
Euder Wayne P. Dugay
Gabrielle C. Rivera
Lloyd Vince Angelo B. Tadeo

Introduction

You are invited to participate in a research study evaluating the user-friendliness of the PowerSync energy monitoring and control system. This form provides information about the study to help you decide whether to participate. Please read it carefully and ask any questions you may have before agreeing to participate.

Purpose of the Study

This study aims to evaluate the user-friendliness of PowerSync's user which is proposed to be implemented within the Technology Transfer and Business Development Office (TTBDO) at Saint Mary's University.

Study Procedures

If you agree to participate, you will be asked to:

1. Complete an online survey evaluating the user interface of the PowerSync Windows application and website.
2. Provide feedback on the system's usability, functionality, and design.
3. The survey will take approximately 5-10 minutes to complete.

Voluntary Participation

Your participation in this study is completely voluntary. You may decline to participate or withdraw from the study at any time without any negative consequences.

Confidentiality and Data Protection

1. No personal information will be collected through the online survey.
2. Survey data will only be used to evaluate and improve the user interface of the PowerSync system.

3. Data collected will be used only until the second semester of the school year 2024-2025, after which it will be disposed of to prevent data leakage.

Participant Consent

By completing and submitting the online survey, you indicate that:

1. You have read and understood the information provided in this consent form.
2. You voluntarily agree to participate in this study.
3. You understand that you can withdraw participating at any time.
4. You consent to the collection and use of your responses for the purposes described above.

You may print a copy of this consent form for your records.

Thank you for considering participation in this research study.

Appendix K Online Survey

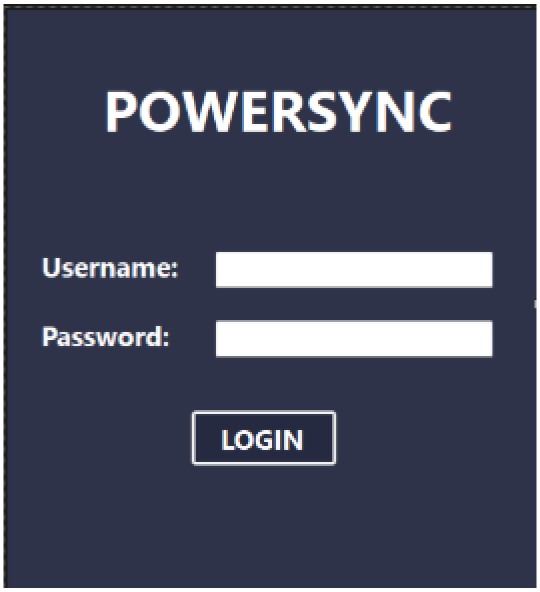
PowerSync: Optimizing Energy Monitoring through Arduino and Raspberry Pi Server-Based Control System

Dear Respondent,

We are currently taking our Thesis 2 entitled: "PowerSync: Optimizing Energy Monitoring through Arduino and Raspberry Pi Sever-Based Control System". The study focuses on the development of a website and a Windows App designed for monitoring and controlling IoT Devices remotely. We, the researchers, humbly request your support and participation by providing us your insights whether our user interface of our website and Windows app are to be labeled as "user friendly" which will aid us for evaluation purposes. The data will be of great help for the completion of our requirements for the degree of Bachelor of Science in Computer Engineering. We appreciate your participation.

Sincerely Yours,
Euder Wayne P. Dugay
Gabrielle C. Rivera
Lloyd Vince Angelo B. Tadeo

Windows App: Log-in



	1	2	3	4	5	
Complicated	○	○	○	○	○	Excellent

Windows App: Dashboard *

	1	2	3	4	5	
Complicated	○	○	○	○	○	Excellent

Windows App: Control Panel *

	1	2	3	4	5	
Complicated	○	○	○	○	○	Excellent

Website: Log-in *

	1	2	3	4	5	
Complicated	○	○	○	○	○	Excellent

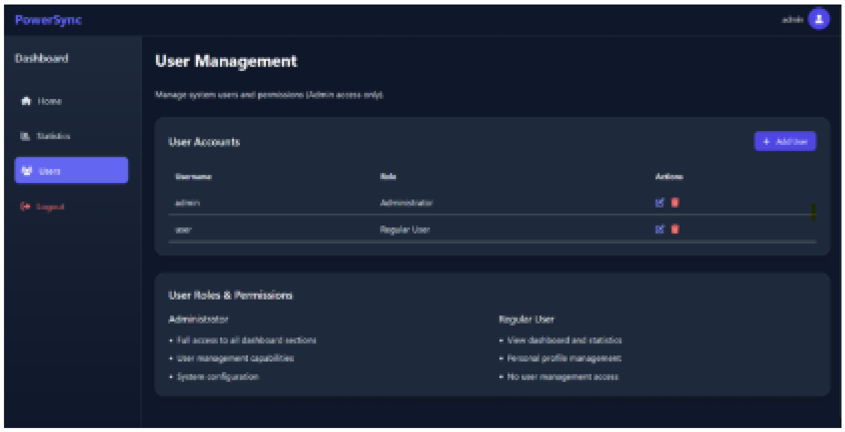
Website: Dashboard *

	1	2	3	4	5	
Complicated	○	○	○	○	○	Excellent

Website: Statistics *

	1	2	3	4	5	
Complicated	○	○	○	○	○	Excellent

Website: Users *



	1	2	3	4	5	
Complicated	○	○	○	○	○	Excellent

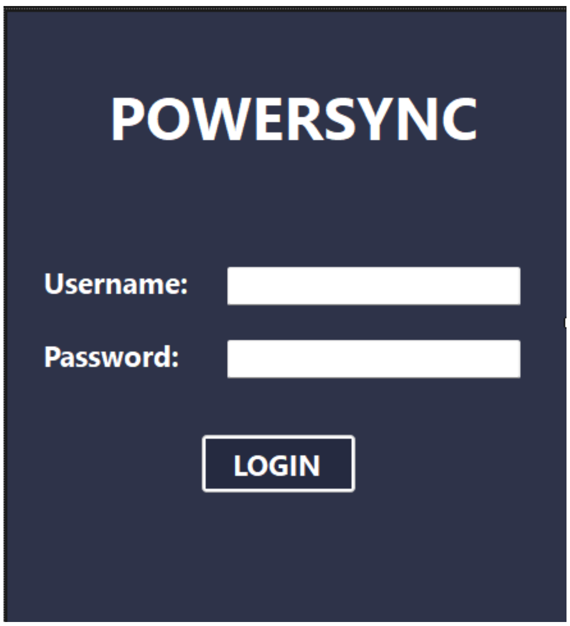
Appendix L User Manual

PowerSync Windows App (Admin/User)

A. Installation

1. Get a copy of the application from a system administrator.
2. Install the app on your computer.
3. Connect to the PowerSync Wi-Fi.

B. Log in



1. Enter username and password given by the administrator.
2. Click Login

C. Dashboard

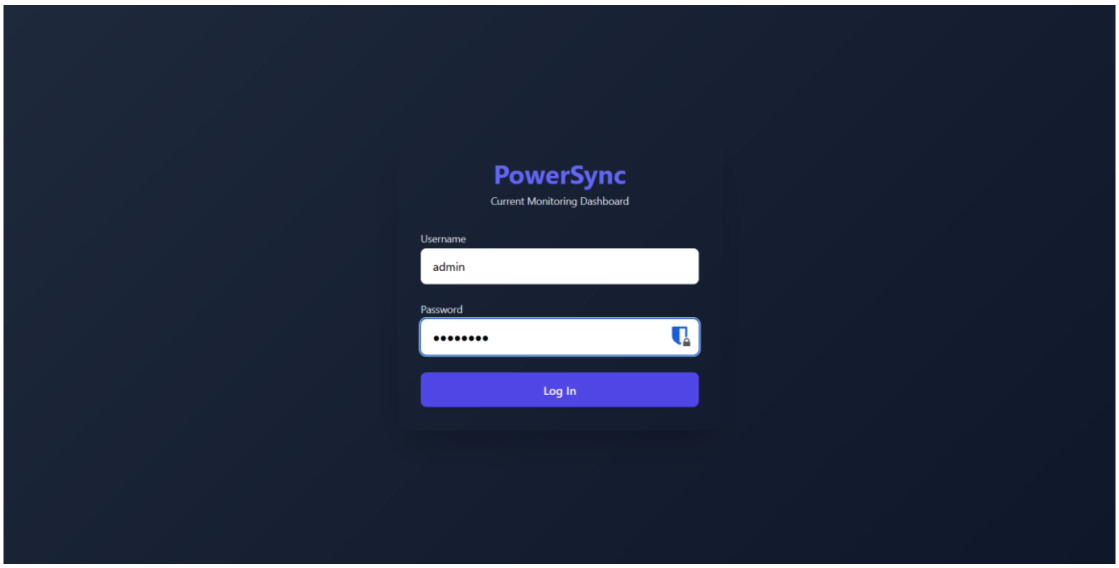
1. The main page is where the user can navigate the dashboard and the control panel.
2. Click the control button to access the control panel.
3. Click the dashboard button to return to the main page.

D. Control System

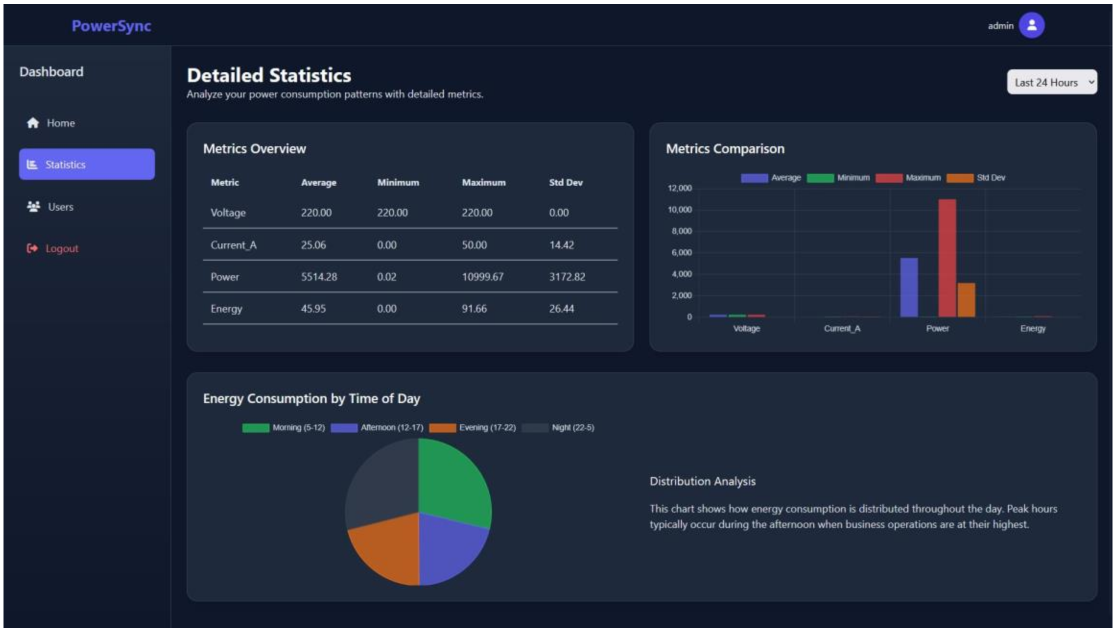
1. The user can navigate between the TTBDO, Bldg A, B, C and D by clicking the dedicated buttons.
2. By clicking these buttons, the user will be able to view the building's layout and control active loads.
3. Click the green button on each panel to turn on active loads and click the red button to turn it off.
4. In cases where a room would be used beyond class hours (9 PM onwards), kindly send a request to the University Administration Office as well as notify school guards.

PowerSync Website

A. Login Page
   1. Enter given username and password.
   2. Click the login button

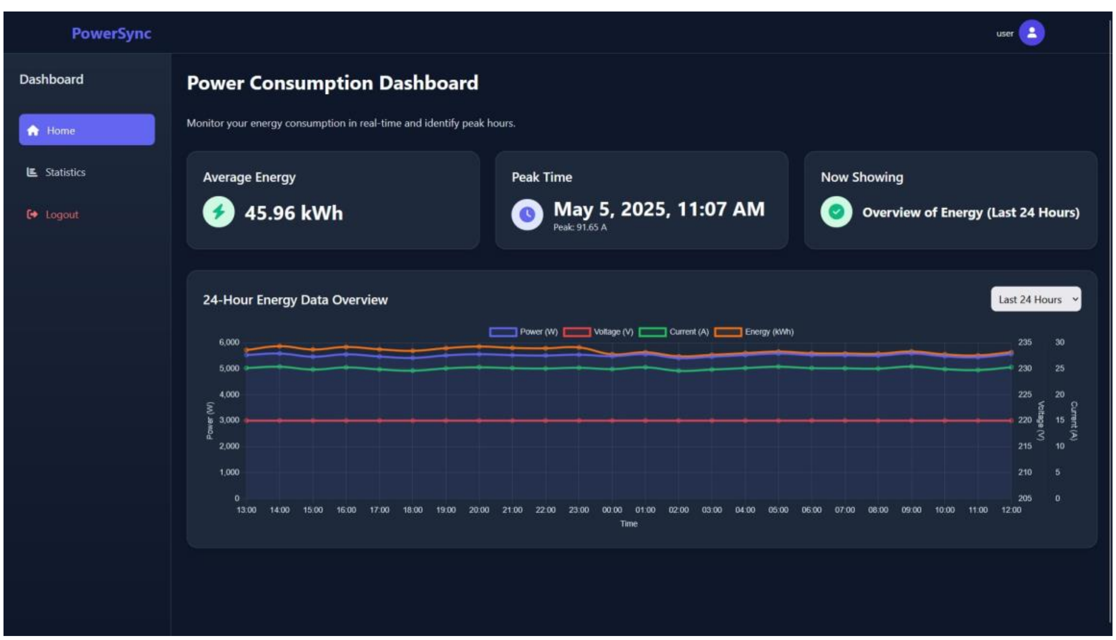


B. Dashboard
   1. Home page – main dashboard where it displays system status.
   2. Statistics – where system statistics are displayed.
   3. Users page(for Admin only) – users can be managed by the admin.
   4. Log out – logs out the current user/admin.
   5. Average current – shows the average current from electrical data.
   6. Peak time – shows the peak time when energy consumption is at its peak.
   7. System status – shows the status of the system.
   8. Time selector – allows the user to display data from the last 24 hours/last 7 days.
   9. Line graph – data visualization.



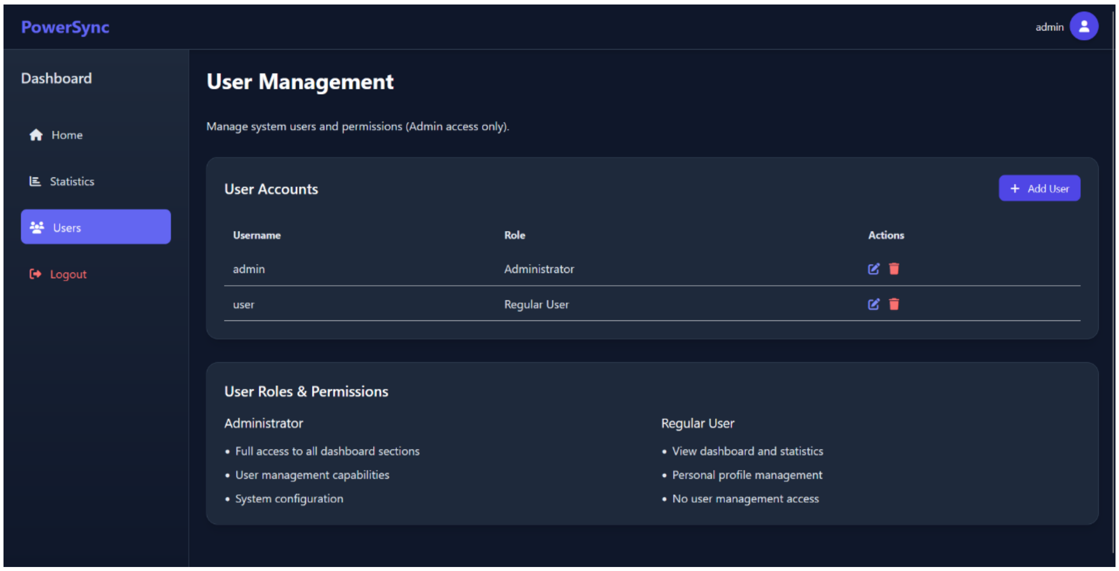
C. Statistics Page

1. Metrics Overview – displays the average, minimum, maximum and standard deviation of electrical data in numbers.
2. Metrics Comparison - displays the average, minimum, maximum and standard deviation of electrical data visually in a bar graph.
3. Current consumption - displays the current consumption by time of day, visually in a pie chart.



D. Users Page (Admin only)

1. Users Account – displays the Admin and the users.
2. Actions – allows the admin to edit or delete users/admin.
3. Add user – allows the admin to create a new user/admin.



OFFICIAL CO-CURRICULAR TRANSCRIPT

Name:	**GABRIELLE C. RIVERA**
Address:	BINTAWAN SUR, VILLAVERDE, N.V.
Email address:	gabriellerivera12129@gmail.com
Contact number:	09495691509

PERSONAL INFORMATION			
Age:	22	Date of Birth:	September 29, 2002
Civil Status:	Single	Place of Birth:	Saudi Arabia
Religion:	Roman Catholic	Father's name:	CARMELITO F. RIVERA JR.
		Mother's name:	JOCELYN C. RIVERA

EDUCATIONAL BACKGROUND		
	Name of School	**Date completed**
Tertiary	SAINT MARY'S UNIVERSITY	2021- PRESENT
Secondary	BINTAWAN NATIONAL HIGH SCHOOL (SENIOR HIGH SCHOOL)	2020-2021
	BINTAWAN NATIONAL HIGH SCHOOL (JUNIOR HIGH SCHOOL)	2017-2019
	TWENTY FIRST CENTURY PRIVATE ACADEMY (JUNIOR HIGH SCHOOL)	2014-2016
Elementary	PISCO PRIVATE SCHOOL	2007-2014

MARIAN CORE VALUES

EXCELLENCE (It refers to academic/ scholastic accomplishments and involvement in non-academic activities wherein the students develop knowledge, competencies, and skills)

Award	**Event / Competition**	**Date**
Participant	SMU x Indra ITIL Introduction	May 2024
Participant	Operational Technology (OT) Network Webinar	2023
Participant	Data Privacy and Security Webinar	2023
Participant	Next-gen connectivity: Inspiring Innovation with 5G technology	2022

INNOVATION (It refers to creative output such as research papers, capstone projects, systems developed, and students' involvement in literary, arts and visual performances)

Involvement	**Seminar / Convention**	**Date**
Participant and Finalist	IDEATECH x UNLEASH	October 16, 2024
Participant	UNLEASH Hack	October 16, 2024
Participant	ICPEP Convention	November 2023
Participant	Mental Health Resiliency Seminar for Graduating Students	September 18, 2024
Participant	Professional FabLab Training: Advance CNC Milling and Prototyping Techniques	December 4-5,2024

COMMUNION (It refers to students' involvement in school and community activities and leadership / trainings attended / conducted)

A. SCHOOL INVOLVEMENT

Designation	**Organization**	**Date**
Secretary	ICPEP.SE SMU Chapter	2024-2025

B. LEADERSHIP TRAININGS/SEMINARS

Involvement	**Seminar / Training**	**Date**
Participant	Youth Leadership Summit	2019

PASSION FOR CHRIST'S MISSION (It refers to students' involvement in spiritual and pastoral activities)

Involvement	**Event**	**Date**
Religious Involvement	Recollection	2023

TECHNICAL SKILLS / COMPETENCIES
Novice Video Editor
Goal-oriented
Adaptable
Willing to learn new ideas
Computer Literate
Java Programmer
C++ Programmer

OFFICIAL CO-CURRICULAR TRANSCRIPT

Name:	**EUDER WAYNE P. DUGAY**
Address:	BONFAL WEST, BAYOMBONG, N.V.
Email address:	euderyugad@gmail.com
Contact number:	09555217019

PERSONAL INFORMATION			
Age:	21	Date of Birth:	April 15, 2003
Civil Status:	Single	Place of Birth:	Bayombong,, Nueva Vizcaya
Religion:	Methodist (Protestant)	Father's name:	EXODUS B. DUGAY
		Mother's name:	ROCHEL P. DUGAY

EDUCATIONAL BACKGROUND

	Name of School	Date completed
Tertiary	Saint Mary's University	2021* PRESENT
Secondary	Saint Mary's University Senior High School	2019-2021
	Saint Mary's University Junior High School and Science High School	2015-2019
Elementary	Bonfal Pilot Central School	2007-2015

MARIAN CORE VALUES

EXCELLENCE (It refers to academic/ scholastic accomplishments and involvement in non-academic activities wherein the students develop knowledge, competencies, and skills)

Award	Event / Competition	Date
Participant	SMU x Indra ITIL Introduction	2024
Participant	Operational Technology (OT) Network Webinar	2023
Participant	Data Privacy and Security Webinar	2023
Participant	Next-gen connectivity: Inspiring Innovation with 5G technology	2022

INNOVATION (It refers to creative output such as research papers, capstone projects, systems developed, and students' involvement in literary, arts and visual performances)

Involvement	Seminar / Convention	Date

Participant	MINDSET Startup Challenge	February 5-8, 2024
Participant	ICPEP Convention	November 2023
Participant	Mental Health Resiliency Seminar for Graduating Students	September 18, 2024

COMMUNION (It refers to students' involvement in school and community activities and leadership / trainings attended / conducted)

C. SCHOOL INVOLVEMENT

Designation	Organization	Date
Finance Executive	ICPEP.SE SMU Chapter	2024-2025

D. LEADERSHIP TRAININGS/SEMINARS

Involvement	Seminar / Training	Date

PASSION FOR CHRIST'S MISSION (It refers to students' involvement in spiritual and pastoral activities)

Involvement	Event	Date
Religious Involvement	Recollection	2023

TECHNICAL SKILLS / COMPETENCIES
Computer System Servicing
Adaptability
Communication Skills
Willing to learn new ideas
Computer Literate

OFFICIAL CO-CURRICULAR TRANSCRIPT

Name:	**LLOYD VINCE ANGELO B. TADEO**
Address:	POBLACION NORTH, SOLANO, NUEVA VIZCAYA
Email address:	lloydangelo1301@gmail.com
Contact number:	09682568720

PERSONAL INFORMATION			
Age:	21	Date of Birth:	January 13, 2003
Civil Status:	Single	Place of Birth:	VRH, Bayombong, Nueva Vizcaya
Religion:	Roman Catholic	Father's name:	EMILREX ANGELO B. TADEO
		Mother's name:	ERLITA JOY S. BAJO

EDUCATIONAL BACKGROUND		
	Name of School	**Date completed**
Tertiary	Saint Mary's University	2021 - present
Secondary	Saint Louis School (Senior High School)	2019 - 2021
	Saint Louis School (Junior High School)	2015 - 2019
Elementary	Saint Louis School	2007- 2015

MARIAN CORE VALUES

EXCELLENCE (It refers to academic/ scholastic accomplishments and involvement in non-academic activities wherein the students develop knowledge, competencies, and skills)

Award	**Event / Competition**	**Date**
Participant	SMU x Indra ITIL Introduction	May 2024
Participant	Operational Technology (OT) Network Webinar	2023
Participant	Data Privacy and Security Webinar	2023
Participant	Next-gen connectivity: Inspiring Innovation with 5G technology	2022

INNOVATION (It refers to creative output such as research papers, capstone projects, systems developed, and students' involvement in literary, arts and visual performances)

Participant	ICPEP Convention	November 2023
Participant	Mental Health Resiliency Seminar for Graduating Students	September 18, 2024
Participant	Professional FabLab Training: Advance CNC Milling and Prototyping Techniques	December 4-5,2024

COMMUNION (It refers to students' involvement in school and community activities and leadership / trainings attended / conducted)

E. SCHOOL INVOLVEMENT

Designation	Organization	Date
4th Year Representative	ICPEP.SE SMU Chapter	2024 - 2025

F. LEADERSHIP TRAININGS/SEMINARS

Involvement	Seminar / Training	Date
Participant	Youth Summit	2024
Participant	Project LEAD	2024

PASSION FOR CHRIST'S MISSION (It refers to students' involvement in spiritual and pastoral activities)

Involvement	Event	Date
Participant	Recollection	2024

TECHNICAL SKILLS / COMPETENCIES
AutoCAD
Sketch-Up
Programming (C++)
Web and App development
Proficiency in Arduino