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SOLAR PANEL RENEWABLE ENERGY DISTRIBUTOR WITH MONITORING SYSTEM USING ARDUINO

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Abstract. The increasing frequency of power interruptions attributed to power supply shortages has become a noticeable trend in recent times. This issue not only disrupts daily life but also poses significant challenges to various industries. In response to this growing concern, the adoption of solar energy emerges as a promising and sustainable solution to mitigate the adverse effects of power shortages.

Solar power systems, having undergone rigorous testing and evaluation over the years, have proven themselves as reliable alternatives. The commendable aspect of solar energy lies in its designation as a clean and renewable source of power, making it a favorable choice for addressing environmental concerns associated with traditional energy sources.

One notable development in the realm of solar technology is the Solar Panel Renewable Energy Distributor with Monitoring System, incorporating cutting-edge features such as Arduino technology. This innovative system underwent a thorough assessment using the ISO25010 quality model, a recognized benchmark for evaluating software and system quality. The system's noteworthy achievement is reflected in its impressive weighted mean rating of 4.17, signaling its acceptance as a viable technology within the IT industry.

This accomplishment not only establishes the Solar Panel Renewable Energy Distributor as a reliable solution but also underscores its alignment with industry standards. The integration of Arduino, a versatile and widely-used open-source electronics platform, further enhances the adaptability and functionality of the system.

As we navigate the challenges of power supply shortages, embracing technologies like the Solar Panel Renewable Energy Distributor becomes imperative for fostering sustainability and resilience in our energy infrastructure. This not only addresses the immediate need for reliable power but also contributes to the global effort in creating a more eco-friendly and sustainable future. The successful convergence of solar energy and advanced monitoring systems exemplifies how innovation can play a pivotal role in overcoming contemporary challenges in the energy sector.

Key Words: Aemilianum College Inc., Arduino, Monitoring System, Real Time Management, Renewable Energy, and Solar Panel

INTRODUCTION

Climate change has undeniably become an inescapable reality, transforming the world as we know it. Its far-reaching impacts are evident worldwide, with news outlets reporting on the destructive consequences of extreme weather conditions affecting climate, economies, and cultures. The prevalence of severe droughts, floods, and intense storms has become an all-too-familiar occurrence, painting a vivid picture of the profound changes underway.

The Philippines, in particular, stands as a highly vulnerable nation in the face of climate change. Exposed to sea-level rise, frequent extreme weather events, escalating temperatures, and intense rainfall, the country grapples with its susceptibility to natural hazards such as cyclones, landslides, floods, and droughts. With major cities and the majority of its population residing along vast coastlines, the Philippines faces an elevated risk, especially considering its location in the world's most cyclone-prone region, experiencing an average of nineteen to twenty cyclones annually, with seven to nine making landfall. Compounding this vulnerability is the accelerated rise in sea levels, surpassing the global average, heightening the threat of storm surges and permanent inundation of low-lying areas.

In response to the urgent need for action, the focus is shifting towards reducing carbon emissions. Embracing solar and renewable energy emerges as a crucial step in diminishing individual carbon footprints. Understanding the causes and consequences of climate change becomes imperative, given that a significant portion of Earth's energy derives from burning fossil fuels, releasing the greenhouse gas carbon dioxide. Solar panels offer a sustainable alternative, producing electricity without emitting any greenhouse gases, although emissions are produced during the manufacturing, material transportation, installation, and maintenance phases of solar energy systems.

Diving into solar technology, two distinct solar harvesting technologies, namely Grid Tie and Hybrid systems, play a pivotal role in generating power. Implementing solar energy systems, such as the Interrupted Solar Panel Renewable Energy Distributor with Monitoring using Arduino (USPRED), can significantly contribute to cost savings in electricity for educational institutions like colleges. However, it is essential to address challenges, such as the intermittent emissions during the life cycle of solar systems.

The project's context reveals the pressing need for a real-time solar energy monitoring information system, emphasizing the economic advantages over time, especially when integrated with internet facilities. The Interrupted Solar Panel Renewable Energy Distributor with Arduino Monitoring (USPRED) not only addresses the challenges of data storage and retrieval but also serves as a valuable research tool and management support for educational institutions like the Camarines Sur Polytechnic Colleges (CSPC).

The purpose and description of the Renewable Energy Distributor Interrupted Solar Panel with Monitoring using Arduino (USPRED) highlight its role as a network-based management system for educational institutions. The project's goal is to automate the storage of solar power system data, ensuring continuity even in the event of computer or system downtime. The use of Arduino technology facilitates data collection, network transmission, and storage in a server database, enabling real-time monitoring, detection of malfunctioning devices, and tracking of system status.

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In essence, the Interrupted Solar Panel Renewable Energy Distributor with Monitoring using Arduino represents a progressive and practical approach to addressing the challenges posed by climate change and energy sustainability, providing a model for other institutions and researchers alike.

Specific Objectives

Specifically, this study aimed to:

1. Design and develop Real time solar energy harvesting System that has;
   1.1 automated Daily/monthly/yearly collection solar harvest Report
   1.2 Real time solar status report
   1.3 Automated report analysis
   1.4 Alarm and notification
   1.5 Display monitoring overview
2. Design and develop ARDUINO device that can collect data place in every Solar desired location.
3. Evaluate / validate the developed system in terms of:
   3.1. functional suitability;
   3.2. performance efficiency;
   3.3. compatibility;
   3.4. usability;
   3.5. reliability;
   3.6. security;
   3.7. maintainability; and
   3.8. portability.

Scope and Delimitation

This study focused on the development of Uninterrupted Solar Panel Renewable Energy Distributor with Monitoring Using Arduino (USPRED), a real time data gathering and monitoring, which can be managed the physical planningoffice of Camarines Sur Polytechnic Colleges, Nabua, Camarines Sur.

The scope of the study was delimited to solar harvesting and monitoring deployed in the deferent areas of the campus. To wit; location in Gymnasium ninety (90) kilowatts grid tie that is generated by four (4) inverter devices where data can be collected and transmit data to the network server. Same process be conducted at Administration and Food Laboratory Building sixty; (60) kilowatts with two (2) inverters and at Library building twenty (20) kilowatts with one (1) inverter, academic building fifty (50) kilowatts Hybrid with three (3) inverter device collect data and can transmit to network server, Green Building fifty seven (57) kilowatt grid tie and highbred, that the highbred ten (10) kilowatt and the remaining forty seven (47) kilowatt is on grid tie with three (3) inverter collected and transmit to network server, the Arduino device use network shield to transmit to network server, use alarm shield sensor for monitoring of devices, also use current sensor to collect the total two hundred seventy seven (277) kilowatt output power and use as monitoring display device installed in desired location.

Significant of the Study

This study is deemed significant for the following:

Educational Institutions. The Camarines Sur Polytechnic Colleges and similar educational institutions benefit from reduced electricity costs, a sustainable energy source, and a practical learning environment for students studying renewable energy and technology.

Students and Researchers. Students gain firsthand experience with cutting-edge technology and sustainable energy solutions, while researchers have access to real-time data for analysis, contributing to academic and practical knowledge in the fields of energy management and renewable resources.

Administrators and Facilities Management. The Physical Planning Office and administrative staff benefit from streamlined energy management, reduced operational costs, and improved maintenance efficiency. Real-time monitoring allows for proactive decision-making and quicker response to any system issues.

Environmental Conservation and Local Community. The local community benefits from a decreased environmental impact and potential improvements in air quality, as the implementation of renewable

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energy contributes to environmental conservation by reducing carbon emissions and reliance on non-renewable energy sources.

Financial Stakeholders. Investors and financial stakeholders may benefit from the long-term cost savings associated with solar energy. The implementation of a monitoring system ensures transparency and accountability in energy usage, providing assurance to those invested in sustainable initiatives.

Utility Companies. By reducing dependence on traditional power sources, utility companies may experience decreased strain on the grid during peak demand periods. This can lead to improved overall grid reliability and reduced pressure on energy infrastructure.

Government and Policymakers. The adoption of renewable energy aligns with national and international sustainability goals. Policymakers benefit from showcasing successful implementations, which can inform and inspire future policies supporting renewable energy and technology adoption.

Technology Providers and Manufacturers. Companies involved in the production of solar panels, Arduino devices, and related technology benefit from increased demand as institutions and organizations adopt solar energy solutions. The study's success may also lead to further innovations and improvements in technology.

Emergency Services and Disaster Response. In regions prone to power interruptions or natural disasters, uninterrupted solar energy systems can provide a reliable power source for emergency services, helping maintain critical operations during challenging circumstances.

General Public. The general public benefits indirectly from reduced environmental impact, as the implementation of solar energy contributes to mitigating climate change. Additionally, the project serves as an example of sustainable practices that can inspire others to adopt similar technologies.

Global Community. The study contributes to the global dialogue on renewable energy and sustainable practices, serving as a model for other institutions worldwide and fostering a broader impact on the global energy landscape.

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METHODOLOGY

Phase 1: Project Planning

The inaugural phase of this comprehensive initiative embarked upon the meticulous planning required to align the project with the overarching goals of the organization. The Solar Panel Renewable Energy Distributor with Monitoring System using Arduino (SPREDMSA) emerged as a product of deliberate analysis and the application of the researcher's wealth of theoretical knowledge, employing both descriptive and developmental research methods. This innovative device was intricately designed to serve as a real-time monitoring system for solar panel harvesting, with a dual purpose of automating the generation of daily, monthly, and yearly harvest reports.

Beyond its fundamental monitoring capabilities, the SPREDMSA was engineered to facilitate the seamless analysis of collected data, providing valuable insights through a user-friendly interface. The multifaceted utility of the device extends to the generation of detailed harvest reports, report analysis, and the provision of alarm notifications in case of anomalies or irregularities in the solar energy system. This holistic approach to monitoring not only enhances operational efficiency but also contributes to a proactive and informed decision-making process.

The user-centric design of the SPREDMSA underscores its commitment to ease of use and convenience. Leveraging advanced programming techniques, the device offers a clear and accessible presentation of data through a Liquid Crystal Display (LCD) and a comprehensive monitoring overview. This not only empowers users to effortlessly navigate and interpret the data but also ensures that the wealth of information collected is readily available for informed decision-making.

In essence, the planning and design phase of the Solar Panel Renewable Energy Distributor with Monitoring System using Arduino not only laid the foundation for achieving organizational goals but also exemplified a commitment to innovation, efficiency, and user-friendliness. The amalgamation of theoretical insights, methodical analysis, and advanced programming techniques culminated in the creation of a sophisticated yet user-friendly solution poised to revolutionize solar panel monitoring and contribute to the broader landscape of renewable energy initiatives.

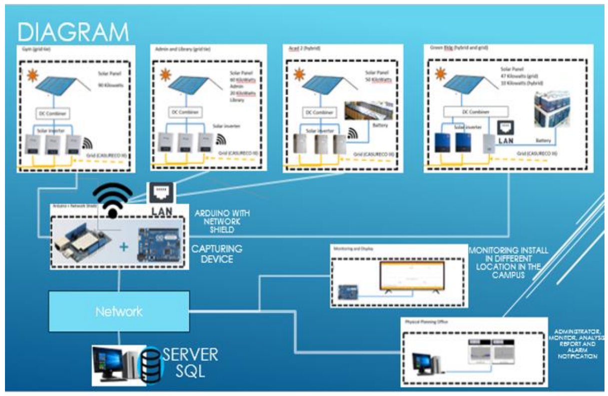

Figure 1 – Connection Diagram

Figure 4.1 illustrates the connection diagram of the developed system. As depicted in the above connection diagram, the system comprised solar harvesting located in various areas, namely the Gymnasium with a capacity of ninety (90) kilowatts grid tie generated by four (4) inverter devices. Here, data could be collected and transmitted to the network server. The same process was replicated in the Administration and Food Laboratory Building, with a capacity of sixty (60) kilowatts and two (2) inverters, as well as in the Library building, with a capacity of twenty (20) kilowatts and one (1) inverter. The academic building, with a capacity of fifty (50) kilowatts Hybrid, utilized three (3) inverter devices for data collection and transmission to the network server. The Green Building, with a total capacity of fifty-seven (57) kilowatts, comprised a hybrid system with ten (10) kilowatts, and the remaining forty-seven (47) kilowatts on grid tie with three (3) inverters, collecting and transmitting data to both the network and the server.

In the system, an Arduino Uno device was employed to convert energy current into raw data, while a network shield was utilized to integrate all solar devices into the network.

Phase 2: Project Requirements

The second phase aims to align the project's resources with the objectives of collecting solar energy deployed in different locations into raw data stored in the system. The benefits of effectively gathering project requirements include time efficiency, accuracy of gathered data, more effective and rapid real-time reporting, and improved technical staff monitoring with alarm and notification capabilities. The researcher procured essential materials to create a system that enhances the collection of solar energy.

The researcher conducted interviews and observations to identify the problems encountered by the Technical Staff at Camarines Sur Polytechnic Colleges, specifically focusing on issues related to the accuracy of time reporting and monitoring. To improve the manual system, necessary equipment such as Arduino devices, sensors, and software requirements were identified. All gathered information was thoroughly analyzed and utilized in the development of the system.

In the final steps, the researcher visited CSPC and interviewed individuals regarding the school's available resources. Based on the gathered information, CSPC possesses sufficient resources to support the system, considering its significant impact on green technology advocacy. Moreover, the fact that the generated current through solar power is monitored ensures sustainability and aligns with the principles of environmentally friendly energy solutions.

Phase 3: Project Design

The research design refers to the overall strategy chosen to integrate the different components of the study in a coherent and logical way, ensuring effective addressing of the research

In this phase, the researcher designed the proposed system to meet the requirements specified in the analysis phase. Additionally, the system architecture was established, defining the components, their interfaces, and functionalities. problem; it constitutes the blueprint for the collection, measurement, and analysis of data. It is crucial to note that the research problem determines the type of design to use, not the other way around.

Details on computer programming languages and environments, application architecture, diagrams, platforms, algorithms, data structures, global type definitions, and interfaces were thoroughly established.

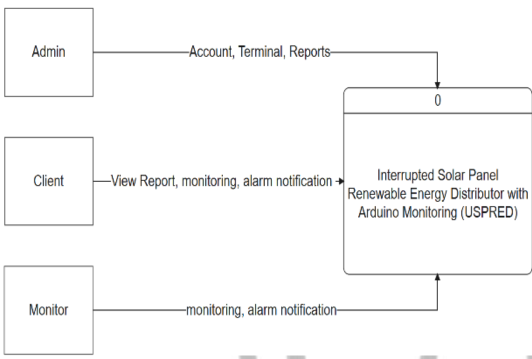

Figure 2 - Context Diagram

Figure 2 displayed the context diagram of the developed system. The diagram illustrated the boundaries of the software system and identified the flows of information between the system and external entities. The entire software system was represented as a single process.

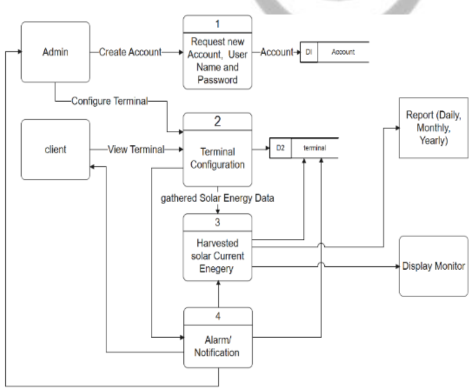

Figure 3 showed the data flow diagram of the system. Flow of information, the functions, or processes, which capture, manipulate, store, and distribute data between a system and its environment, as well as between its components, were graphically represented in this diagram. It was a good communication tool between the user and the system designer because of the visual representation. Data Flow Diagram's structure allowed you to start with a broad overview and work your way down to a hierarchy of detailed diagrams. The data flow diagram (DFD) depicted how data flows through an information system, but not the program logic or processing steps. It offered a logical model that demonstrated what the system does rather than how it does things.

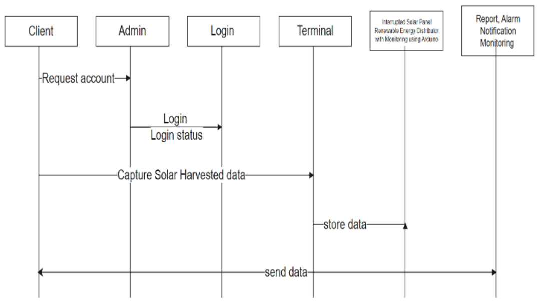

Figure 4 Sequence Diagram

Figure 4 displayed the sequence diagram of the developed system. It depicted the interactions between objects in the sequential order in which those interactions occur, illustrating how the system collaborated.

Design of the Device

The supply section which is the ranging from 9 to 12 volts that supply Arduino and use LM7809 regulator transistor IC that regulates stable power good 9 volts, Arduino device 3.3 to 5 volts . which supplied the controller and the sensors; the Current voltage sensor which measured the 220 volts from inverter/combiner, the CT Current Clamp sensor which measured the current consumption

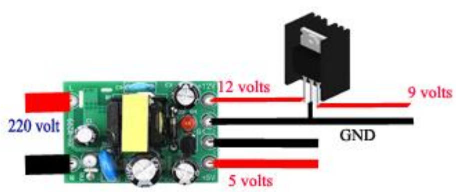

Figure 5 - Power Supply

Figure 5 illustrated the Power Supply used by the Solar Panel Renewable Energy Distributor with Monitoring System using Arduino.

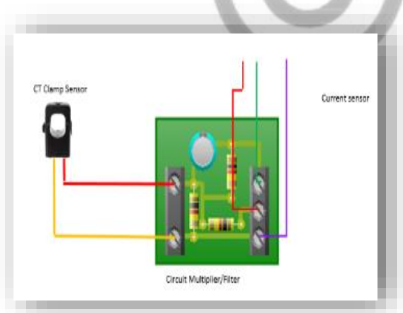

Figure 6- Circuit Multiplier/Filter

Figure 6 displayed the Circuit Multiplier/Filter that converts AC-to-DC voltages.

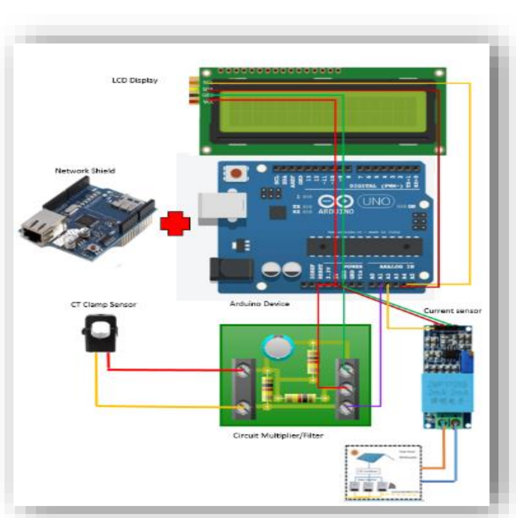

Figure 7 displayed the schematic diagram of the Solar Panel Renewable Energy Distributor with Monitoring System using Arduino.

The researcher of this project were guided by the diagram of the whole operation to achieve the desired function of the system. It helped the researcher determine if a trouble has been encountered and assist them on the operation sequence.

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Figure 7- Schematic Diagram of the Solar Panel Renewable Energy Distributor with Monitoring System using Arduino

Phase 4: Project Development

It is expected that in developing, patience is required. Sometimes, the system work and sometimes it does not. But the researcher was patient and determined to finish the project. With all the support from the workplace and inspirations from the family, the researcher was successful in finishing the goals being required by the project.

The following screenshots were the proof of the system that was developed:

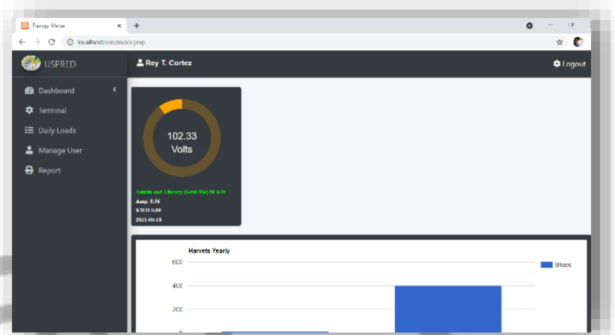

Figure 8 - System's Dashboard

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Figure 4.8 showed the system's dashboard in which it displayed monitoring, such as the Info board display, leather wall, and the kiosk in various places.

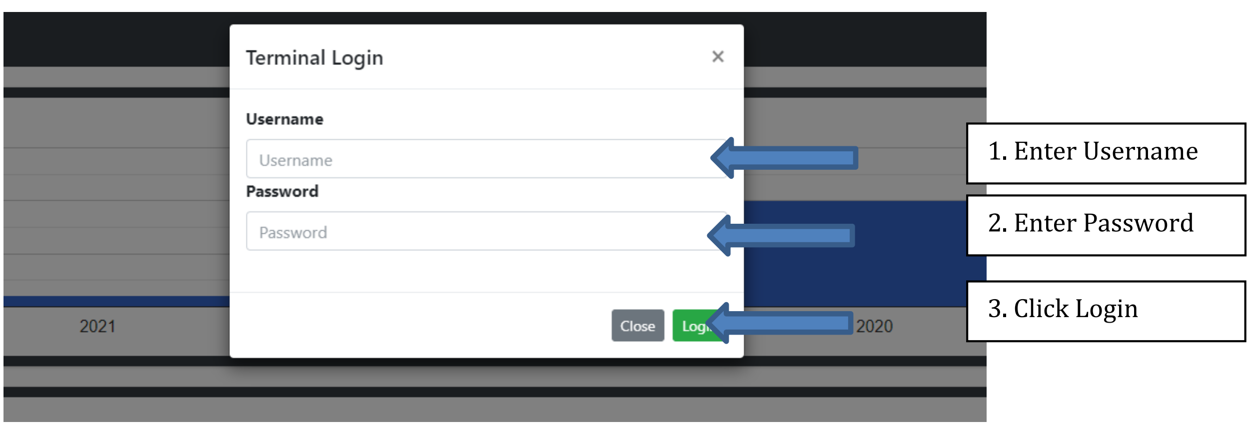

Figure 9 - Dialogue Box

Figure 4.9 depicted the login dialog box, which required the user name and password to be entered.

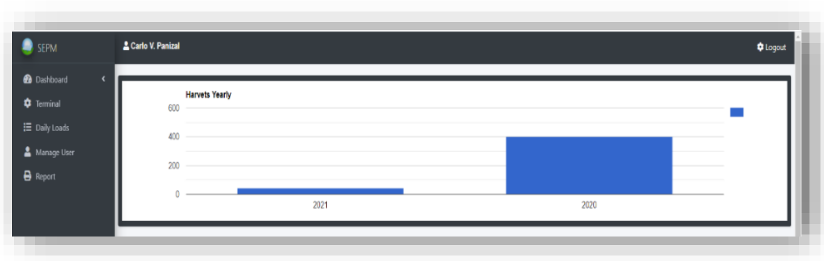

Figure 10- Logout Button

Figure 4.10 displayed logout button, closing the dialog box, returning to the dashboard, and displaying the monitoring display function.

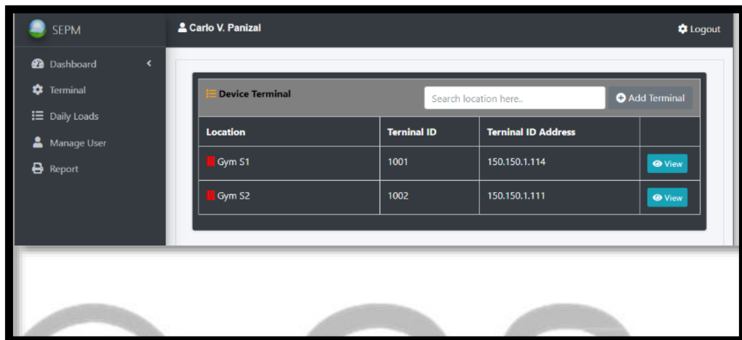

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Figure 11 - Terminal Menu

Figure 11 displayed the terminal menu where the admin can add, edit, delete, save inofrmation. The terminal detected the connected Arduino device, which detected converted solar power into data, and saved it into the database. Search terminal, the client can view. The customer access to the terminal device installed to monitor this section.

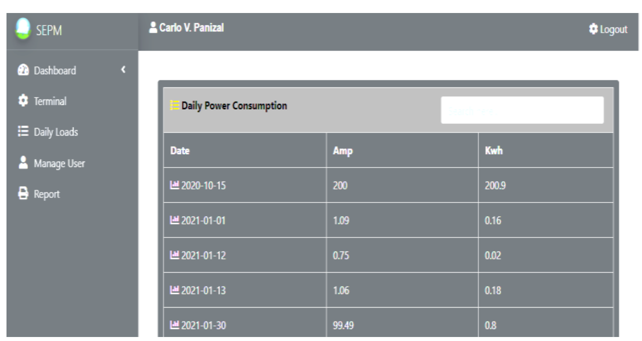

Figure 12 - Daily Loads

Figure 12 showed the daily loads where the system automatically gathered all the terminal solar harvested energy data, it displayed total daily consumption and store to database.

The process of capturing data send by the terminal transmit per seconds and automatically add data in one database. The terminal converted the total harvested energy which was turned into data by getting pulse frequency. Signals then were transmitted to the multiplier where they were filtered to the circuit ro ensure that the current produced is the same as the data converted. The filter cuts the surge voltage to peek voltage.

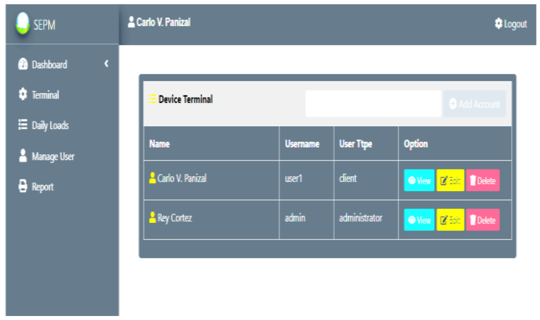

Figure 13 - Manage User Module

Figure 13 showed the Manage User Module that can add, edit, delete, update and save option to manage account and access to the system. The admin access level grants all the access to the system, the client access level obtained access level viewing, searching, monitoring.

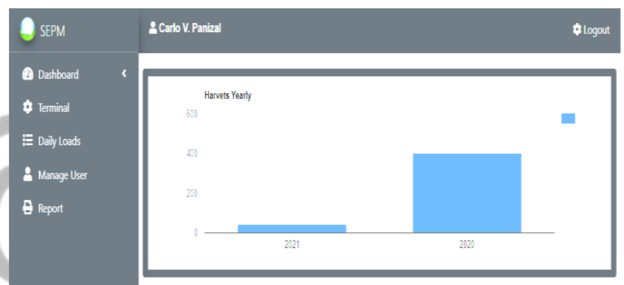

Figure 14 - Report Module

Figure 14 - This figure showed the reports generated by the system, yearly, monthly, daily report in real time display which is a network based system.

Summary of Findings

The following findings were obtained from the study:

1. The automated system for collecting solar energy on a daily, monthly, and yearly basis has proven successful. It includes a real-time solar status report, providing specific information on the stored solar energy. Stakeholders are promptly notified through a monitoring overview, ensuring an ample and reliable energy supply.
2. Upon presentation to the identified evaluators, it was determined that the developed system is suitable for harvesting solar energy, providing benefits to the end-user. The system received a favorable rating of 4.17 weighted mean from evaluators using the ISO 25010 quality model.

Conclusions

Based on the findings of this study the following conclusions are formulated:

1. The developed system, with its advanced features, now aligns with technologies that store and harvest solar energy for daily activities requiring its services.

2. The Solar Panel Renewable Energy Distributor with Monitoring System using Arduino successfully underwent evaluation by two sets of assessors: IT experts and potential clients of the device or system.

Recommendations

Based on the conclusions, the following recommendation are hereby offered:

1. The Solar Panel Renewable Energy Distributor with Monitoring System using Arduino is versatile and suitable for use in various establishments, households, and by individuals seeking to experience its services.
2. With a favorable rating of 4.17, denoting "Acceptable" for usage by evaluators, this device is poised to address energy issues for households and establishments facing power interruptions.

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