SMART SOLAR BASED CBT EXAMINATION MONITORING SYSTEM

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CERTIFICATION

This is to certify that this project was carried out by **ABIODUN, OLATADE OLALUDE** with the matriculation number: **HND/23/COM/FT/0241** in the Department of Computer Science, Institute of Information and Communication Technology, Kwara State Polytechnic, Ilorin, Kwara State.

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DEDICATION

I dedicate this project work to the Almighty God and my beloved Grandma Mrs Alamu Alice, Who guided and motivated me, shaping my path throughout my academic journey at Kwara State polytechnic.

ACKNOWLEDGEMENT

All praise is due to the Almighty God, the Lord of the universe. I praise Him and thank Him for giving me the strength and knowledge to complete my HND program and also for my continued existence on earth.

I appreciate the utmost effort of my supervisor, **Dr. Agboola, O. M.** whose patience, support, and encouragement were the driving force behind the success of this research work. He gave useful corrections, constructive criticisms, comments, recommendations, and advice and always ensures that excellent research is done. My sincere gratitude also goes to the Head of Department, **Mr. Oyedepo, F. S.,** and other members of staff of the Department of Computer Science, Kwara State Polytechnic, Ilorin for their constant cooperation, constructive criticisms, and encouragement throughout the program.

Special gratitude to my parents, who exhibited immeasurable financial, support patience,, prayers, and understanding during the period in which I was busy tirelessly with my studies, special thanks go to my lovely siblings

My sincere appreciation goes to my friends and classmates.

ABSTRACT

This study investigates the deployment of a solar-powered CCTV surveillance system to enhance examination monitoring in educational institutions, addressing the limitations of traditional manual invigilation that often fail to curb malpractice. The research aims to provide a sustainable, reliable, and efficient solution to uphold examination integrity by integrating solar energy with advanced surveillance technology. The proposed system incorporates solar panels, batteries, inverters, and high-definition CCTV cameras, ensuring continuous operation during power outages. The methodology encompasses system design, installation, configuration, and maintenance, prioritizing user-friendliness and operational efficiency. A comparative analysis of existing invigilation methods revealed vulnerabilities, including inconsistent monitoring and susceptibility to cheating, which the new system mitigates through real-time, high-quality surveillance. Results demonstrate that the solar-powered CCTV system significantly reduces examination malpractice while lowering operational costs through renewable energy utilization, aligning with sustainability objectives. The system's intuitive interface and comprehensive maintenance protocols support its seamless adoption and long-term functionality in educational settings. Challenges such as initial installation costs and the need for technical training were identified, with recommendations for subsidized implementation and staff development programs. This study concludes that the solar-powered CCTV system offers a transformative approach to examination monitoring, fostering a secure, fair, and environmentally conscious assessment environment. It advocates for widespread adoption in educational institutions, supported by regular maintenance, staff training, and further research to optimize system performance. The findings contribute to the discourse on leveraging technology for academic integrity and sustainable development.

Keywords: Surveillance system, Examination Monitoring, Solar-powered technology, Examination malpractice prevention and traditional manual invigilation.

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CHAPTER ONE

1.0 Introduction

In today's digital age, technology has revolutionized the way we conduct examinations, computer-based tests (CBT) have emerged as a popular method to offer efficiency, accuracy and scalability. However, assuring the integrity of online examinations remains a significant challenge. Traditional monitoring methods often rely on human invigilators, which can be labor- intensive, prone to human error, and susceptible to malpractice. The rapid advancement of ICT in education has resulted in a transformation in the way activities are being performed today. One of such activities is the assessment of students which has evolved from the use of paper and pencil to a computer-based format in recent years, (Dietal et al, 2020) defined assessment as any method used to understand the current knowledge that a student possesses.

Examination monitoring plays a crucial role in maintaining academic integrity and ensuring fair assessment practices. It involves the surveillance of students during the examination process to prevent cheating, malpractice and unauthorized assistance. Effective monitoring not only safeguards the credibility of education institutions but promotes a level playing field for all students. According to CCTV technology, CCTV systems offer capabilities of surveillance that can be utilized for the purpose of protecting people, assets and other systems. The primary function of a closed-circuit television (CCTV) system is to act as a security force multiplier by providing surveillance for a larger area and for a greater portion of the time that would be possible with security personnel alone. Using CCTV as surveillance in examination monitoring systems helps in conducting efficient invigilation, which can help prevent exam cheating from occurring (Eziechina, Ugboasa & Esiagu, 2017).

To address the limitation of traditional examination monitoring systems, the introduction of a smart Solar- Based examination monitoring system presents a novel approach; this system harnesses the power of renewable energy, specifically solar power, to provide a sustainable solution for secure and efficient examination monitoring. Solar power derived from harnessing sunlight, has gained significant traction as a clean and renewable energy source. Solar Photovoltaic (PV) systems convert sunlight into electricity, reducing reliance on fossil fuels and mitigating greenhouse gas into emission. By integrating solar power into examination systems, we can ensure uninterrupted power supply, especially in remote areas or during power outages. As the world increasingly shifts towards renewable energy sources, Solar integration represents a practical step towards a greener future (Requia, Mohamed, Higgins, Aruin, & Ferguson, 2018).

1.1 Statement of the Problem

The increasing reliance on Computer-based Test (CBT) has transformed the examination landscape, while CBT offers numerous advantages, efficiency and accuracy. It also present significant challenges, particularly in terms of power supply and monitoring to ensure examination integrity.

Power outages disrupt the smooth conduct of CBT examinations, leading to delays, data loss, potential system failure and traditional monitoring method, often relying on manual processes, physical infrastructure, human invigilators which leads to error, lapses in attention, potentially compromising the seemingly of the examination process.

1.2 Aim and Objectives

The aim of the design is implementation of Solar powered CBT examination system with the objectives of;

1. Installation of solar panel, surveillance Camera and inverter for the monitoring of the CBT examination center; and

2. Connection of solar panels with the batteries installation.

1.3 Significance of the Study

i. Uninterrupted power supply: Solar power provides a reliable and sustainable energy source, reducing dependence on grid electricity and minimizing disruptions caused by power outages.
ii. Real-time monitoring: Solar powered surveillance cameras will provide continuous, real-time monitoring of examination halls, enabling time detection and prevention of malpractice.

1.4 Scope of the Study

The scope of the study is that we installed a smart solar CBT examination monitoring system at the Kwara State Polytechnic Department of Computer Science CBT examination hall. This system enhances exam integrity through real-time monitoring, powered by sustainable solar energy, ensuring reliable and efficient operation..

1.5 Organization of the Study

This research is organized into five Chapters, Chapter one involves general introduction of the study, statement of the problem, aim and objectives of the study, significance of the study and scope of the study.

Chapter two presents a review of related literature on examination monitoring systems; it includes Solar energy technologies and Internet of things (IOT) and critical analysis of existing systems and their limitations.

Chapter three presents research methodology used, research design, collection of data, installation of proposed system, and analysis of the existing system and data analysis.

Chapter four present result of the design, implementation and output result.

Chapter five contains the summary of findings, conclusion of the findings and recommendations of future research.

1.6 Definition of Terms

- **CBT**: Computer-Based Test (CBT) refers to the use of computers to administer and score tests or scans.
- **Solar Photovoltaic**: also known as PV, is the conversion of sunlight into electricity using semiconducting materials that exhibit the photovoltaic effect.
- **Assessment**: is the process of gathering and interpreting information about a person's abilities, knowledge or performance.
- **Examination**: is a formal assessment used to measure a person’s knowledge, skills or classification in a specific subject.
- **Monitoring**: This is the act of observing something overtime with the intent of detecting changes.
- **CCTV**: Closed - Circuit Television; is a video surveillance system that monitors activities within a specific area, such as public space or building.
- **Surveillance**: A closer look, it is the monitoring of behavior activities for the purpose of gathering information.
- **Solar panel**: A device that converts sunlight into electricity.

Chapter Two

2.0 Literature Review

Joshua, Abdul Karim, Yusuf and Suleiman (2022) worked on design and implementation of computer based Testing systems. The aim of the study is to design and implement a computer based testing system (CBTS) . One of the objectives of the design system is to eliminate the time spent in making and transmission of student results, reducing the cost of printing question papers and answer booklets.

The methodology of the design required tools to aid the development of the proposed system include use of case diagram, dataflow, flow chart and database design. The design described that the admin has to manage users' courses, examinations as well as the compilation of the result in the system while the users can login into the system and write his/her examination. After final submission of the answers, the user can have direct access to his/her results online. The finding of the researcher was conducted through interview and questionnaire and the result of the analysis comprised a lot of problems with the old system. The new proposed is easy to use and flexible compared to the old system. The gaps of the findings associated with the new proposed system is that it requires training and support for administrators, data storage and security measures because of the data sensitivities and it requires adequate troubleshooting of the system. In conclusion, the proposed system was fully implemented which drastically reduced bribe-taking by lecturers, invigilators and supervisors. The researchers recommend addressing the limitation of the current application by incorporating online collation of results from various courses examined,compute cumulative Grade point aggregate (CGPA) and generation of transcripts with necessary security features to foster implementation of distance education.

Franklin and Getty(2023)worked on ICT tools based examination monitoring system.The delta state University example. The aim is to design ICT tools scammonation monitoring is to prevent cheating and maintain scamination security with the use of web cam and audio recording. The methodology of the design is, The United software development was used in this paper. Due to the component based approach to development. The finished application consists of interconnected software component. These components are connected via well defined interfaces and use if visualization tools like the VML are invaluable in creating in functional system architecture, with conducting CBT scans system. The process of implantation are start, collect login details, initialize processor with all interfaces, start timers for scam clock, initialize webcom and audio record, end scam, save answers, end. The finding of the researches is during the test, pictures, audio, and video of student were captured and save. Conclusion, it can be very beneficial for the management of student data during scans to utilize the proposed system. The used of ICT tools in the examination system will significantly reduce the amount of effort required by scamination administrator. Recommendation, the use of CCTV surveillance system will help prevent scam malpractice and create a better environment for scamination

Eric, Brandon and David (2023) researched on CCTV surveillance for crime prevention. The aim is to implement CCTV surveillance for crime prevention .One of the objectives of the implementation is using CCTV as surveillance to helps to detect crime and identify suspects. The methodology of the design, the research use systematic review, using a rigorous approach for locating appraising and synthesizing evidence from prior evaluation studies. Studies were selected for illusion in the review according to the following four criteria; CCTV was tube main focus of the intervention, the evaluation used an outcome measuring crime, The research design involved, at minimum, before and after measures of crime in treatment and pre invention. The findings show that CCTV is associated with a significant and modest decrease in crime and gaps of the finding associate with the implementation of using CCTV as surveillance is CCTV cameras may not cover all areas. Conclusion, in one systematic review, researchers identified 80 students that met the inclusion criteria, with 76 providing the required data to be included in the meta analysis. The results of pooled efforts polled effect meta analysis shows that CCTV is associated with a modest and significant reduction in crime. Recommendations, research should expand the focus of CCTV evaluation to Include more outcome measure than crime prevention

Asimobi (2022) worked on implementation of an IP camera for federal University of technology Owerri. The aim is to install cameras for security surveillance. One of the objectives of the design is to enhance the idea and conception of using computerized surveillance systems in the classes. In a situation where the examination halls are well equipped with CCTV cameras and full conduction of biometric mechanisms, examination malpractice will be curbed to a great rate. The methodology of the design, the researcher used various means to have an overview of the current system associated with examination check. The researcher used the interview method, observation method and examination of existing records/ record view and background reading method. The findings of the researcher is, the growth of this menace of malpractice in federal university of technology Owerri (FUTO) back to time immemorial. The gaps of the funding is, the current system is a manual system, where errors are bound to occur. it involves eye to eye invigilation. Conclusion, to combat the issue of examination malpractice in school, the use of Manual system invigilation should be dropped, it has not proven 60% efficiency since its introduction. The end product of it worth venturing as ii will aid the institution to achieve and maintain integrity. The researcher recommendation of this study springs up from the outright benefits that are achievable if the courses of research are implemented. Also the Government should provide sufficient and continued financial support to enable institutions to employ computer technology in necessary areas of concern.

Nayana and shashidhar (2019) Worked on Smart Door system. The aim of the design is to implement a smart door lock security system. One of the objectives of the proposed system is to provide a secure and reliable locking mechanism to prevent an authorised access and easy to use locking system that can be controlled remotely. The methodology of the proposed system use GSM based systems, motion detector, visual basic system, biometric type, password based system, the mechanic door lock, controller devices, wiring and connector.The steps of the proposed system are as follows, person who want to enter the room should enter his registered mobile number then OTP generate by the system,OTP sends to user mobile number, OTP enter through the keypad on the door, if mobile is off, enter zero through the keypad, then security question will ask by the system, answer the security questions, fingerprint verification takes place and if the matches then the door opens. The findings of the researcher in the proposed system is that fingerprint authentication is a reliable and secure method for verifying user identity and one of the gaps of the findings is, it's vulnerable to spoofing attacks of the fingerprint authentication system, where attackers disguise themselves as a legitimate user. Conclusion, the automated door lock system is implemented using arduino, finger sensor and GSM module for OTP transmission and reception. This work is less expensive and easy to implement so that common man can also get high security and the application of this system can be used in offices, banks etc. The recommendation, using a combination of finger authentication, OTP and password authentication to provide an additional layer of security.

Vincent,Uchenna,Nwakamma and Olawe(2023) worked on Advance Solar Integration in security and Alarm system:A review of innovations and challenges. One of the objectives of integrating solar systems to security and alarm systems is to provide continuous power to secure devices and enhance security surveillance. The methodology used in the review pawer involves a comprehensive examination of the integration of solar power into security and alarm systems. The researcher conducts a site assessment to determine the solar resources availability, the security and alarm system requirements and they ensure all components are compatible and meet the system requirement. The researcher installed solar panels and monitoring systems, installed the batteries, charger controllers and installed the alarm system components including sensors, sirens, control panels and connected the solar-powered system to the alarm system. The findings of the researcher are able to harvest energy from the sun and reduce reliance on non-renewable energy sourced. The gaps of the findings from the publication by the researchers result in interference of power supply during periods of low sunlight or at night and the researchers were able to conclude that integration of solar power into security and alarm systems helps to enhance security and contribute to economic saving and environmental sustainability. The researchers recommend that the regulatory framework should evolve to encourage the adoption of solar technology while ensuring safety and standard compliance. The researchers also recommend the development of predictive maintenance solutions that minimize system downtime.

Ehiglannuose, Cyril and idiata (2022) worked on the effect of CCTV system in examination monitoring in institutions of higher learning:A case study of Edo state polytechnic. One of the objectives of using CCTV in examination monitoring systems is to minimize and completely eradicate the problem of examination malpractice during examination and get students aware and conscious that they are being watched during the entire duration of the exams. The methodology used used during the implementation of CCTV for examination monitoring includes the procurement and installation of the gadget as the first stage, the second stage was development of the questionnaires to students and third stage was the administration of questionnaire to students to ascertain their perception on this development and the final stage was the administered questionnaire been collected and them analysed by simple statistical analysis for discussion. The findings of the researchers states that implementation of CCTV during examinations helps to reduce examination malpractice, enhance security of the examination environment and increase transparency, accountability of the examination process. The gaps of the funding was implementation of CCTV dependence on electricity supply, which can be a concern in areas with frequent power outages and the design is expensive to implement. The researcher concluded that student’s responses show that examination malpractice is not a good practice and students believe that examination malpractice is not easy and cheap and not every student that engages in malpractice passes. The decline in examination malpractice will boost confidence in students. The researchers recommendation, in order to protect students and staff data security measures should be put in place and establish a clear policy on the use of CCTV cameras for examination monitoring.

Obi Nneka (2022) worked on solar monitoring system reliability: challenges and prospects for modern engineering. The aim of the project is to design an IOT based solar power monitoring system that allows for automated solar power monitoring and control. One of the objectives of the design is to track the performance of solar panels, inverters and other system components to identify potential issues, optimize energy production and to help to detect faults in Solar panel design systems. The methodology of the design uses a prototype system with different parameters of the solar panel like voltage, current, power and the temperature are monitored. This system is designed using Arduino Nuno controllers.The voltage is monitored using a voltage divider principle, current is measured using ACs712 current sensor and temperature by temperature sensors LM35. The designed prototype integrate voltage and current sensor to measures both voltage and current out of Solar panel and incorporate with temperature sensor to be able to monitor the amount of radiation from the sun and equivalent it to solar panel output and the findings of the researcher helps to improved energy access and enhanced efficiency of the solar power system and the gap of the findings highlighted in the publication is inadequate to visualise solar power system parameter and it was conclude on focusing on examination some of the challenges of solar monitoring system reliability with a view of develops effective framework in modern engineering and sustainability. The study applied the concept of IOT and tried to monitor solar panel parameters and other parameter related solar power operation such as temperature, maintenance with the help of IOT and Thinkspeak open source IOT platform. The researcher recommended in the publication that provision of advanced remotely managed solar photovoltaic cell systems for various operations like remote shutdown.

Abdullah,Muneer and Suleiman (2021) Worked on smart security door system using SMS based energy harvest. The aim is to design and implement a security door system using SMS based energy harvest. One of the objectives of the proposed system is to send real time alerts to authorized users via SMS in case of unauthorized access attempts or other security breaches. The methodology of the study is divided into two stages, the security and energy harvest side. The security stages comprises the code of intruder detection sensor, password generation, keypad, a display unit, led indicators an alarm system and SMS sender module while energy harvest stages described the energy harvest side of the system. This side of the code is programmed to real analog data from DC generator and battery which are to send to the computer (MATLAB) for display and analysis purposes. The program begins with a declaration of all necessary parameters on MATLAB and Arduino mega microcontroller while part and bond rate were set to match. The findings of the researchers in SMS based security door system using energy harvesting provides security and energy efficiency while the gaps of the findings is insufficient evaluation of energy harvesting. Conclusion, smart security door energy harvest system is a multi-purpose system designed to improve entrance door security yet scavenge electricity from the door. It comprises two major sections, which are the security side and the energy harvest side . According to the developed security side, the door is described to sense the presence of human activity at its entrance with SMS sending capability. The investigation includes different ways that security can achieve various patterns to utilize a rotational motion to generate electricity. Recommendation, mobile application energy harvest and security monitoring can be introduced to remotely monitor a mobile application like Android App and iOS and attaching a camera to the system will help to identify the person who stands up in front of the door and the SMS to the propricity owner.

Suiful, Kabir, Saifu and Hassan (2023) Worked on design and construction of a solar based home automation system with Bluetooth module. The aim is to design a solar based home automation system with a Bluetooth module that can efficiently control and monitor various home appliances remotely.one of the objectives of solar based home automation system with Bluetooth module is to efficiency generate and store energy for the home automation system and the methodology of the design is using GSM base smart gardening system that utilize cellular network to remotely monitor and control gardening system. The micro- controller and other mechanisms are collaborated according to its required program. The list of the required materials is a 2 pin plug, solar panel, inverter, charger controller, battery, relay, timer, magnetic contactor, power supply, Arduino UNO, motor drive, IR sensor, Bluetooth and many sensor powered integration materials. An intelligent home appliance connects the remote control with mobile or remote control to a home reliever to complete the interface design approach,the microcontroller and the arduino were used for controlling some applications in the home manually via a remote control and automatically use different sensors for each device. The findings of the researcher showed that it can efficiently control and monitor various home appliances remotely and gaps of the findings states that it was only tested in a small-scale setting and its cyber security vulnerability. Conclusion, controlling home appliances via Bluetooth have been presented in this research and they recommend based on the findings of the study on the solar-based home automation system with Bluetooth modules that the system should be scalable to accommodate larger-scale applications and develop maintenance plans to ensure the system long-term sustainability.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Introduction

We connect solar panels to generate DC power, which connects to a charge controller via low-resistance copper cables (e.g., 10 AWG) to regulate voltage and prevent battery overcharging. The charge controller links to a deep-cycle battery 12V lithium-ion for power storage. An inverter converts battery DC to AC for devices like DVRs and monitors, connected via standard power cables. For data, CCTV cameras use Ethernet cables (Cat5e/Cat6) with RJ45 connectors to a PoE switch for power and data transmission. Coaxial cables with BNC connectors can link analog cameras to the DVR, while optical fiber offers high-bandwidth data transfer for long distances. The DVR processes video signals, outputting to a monitor via VGA cables for display. To ensure proper cable sizing and orientation for optimal solar efficiency.

3.2 System Architecture

The approach is divided into two interconnected categories: (1) solar power installation and (2) CCTV system installation. Each category is detailed with materials, procedural steps, and their interdependencies, ensuring a robust and replicable research framework.

1. Installation of Solar-Powered System

The solar-powered system serves as the backbone of the Smart Solar CBT Examination Monitoring System, providing an autonomous and renewable energy source to power the CCTV infrastructure and potentially other examination-related equipment. The methodology for this category is structured as follows:

The solar-powered system harvests sunlight via the PV panels, generating DC electricity that flows to the charge controller. The MPPT algorithm optimizes this energy, directing it to charge the battery. The stored energy in the battery is then converted to AC by the inverter, providing a stable power supply to the CCTV system.

This setup ensures uninterrupted operation, with the 560 W panel capacity and 100–200 Ah battery supporting a typical CCTV load (e.g., 50 W) for 10–20 hours without sunlight, depending on battery size and efficiency losses (typically 10–20%).

2. Installation of CCTV System

The CCTV system is designed to monitor the CBT examination environment, leveraging the solar-powered infrastructure for continuous operation. This category integrates surveillance hardware with the energy system, ensuring real-time recording and remote accessibility

The CCTV system relies on the solar-powered infrastructure for electricity, with the inverter supplying AC power to the PoE switch, NVR/DVR, and router. The PoE switch distributes power and data to the cameras via Ethernet cables, simplifying installation and reducing energy losses. Video data from the cameras are transmitted to the DVR for storage and processing, while the router enables real-time monitoring over a secure network. This integration ensures that the surveillance system operates seamlessly, even in off-grid scenarios, with the solar system providing sufficient power for 24/7 functionality.

3.3 Interconnectivity Between Solar and CCTV Systems

The synergy between the solar-powered and CCTV systems is central to the Smart Solar CBT Examination Monitoring System. The solar panels and battery provide a sustainable energy reservoir, managed by the charge controller and inverter, to meet the CCTV system's power demands (estimated at 50–100 W, including cameras, switch, NVR, and router). The inverter's AC output is distributed to the PoE switch and NVR/DVR, while DC options can power low-voltage components directly. Data flow within the CCTV system is independent of the power source but relies on the stability of the solar-powered supply to prevent interruptions. This interconnected design ensures energy autonomy, operational reliability, and enhanced security for CBT environments.

CHAPTER FOUR

SYSTEM DESIGN AND IMPLEMENTATION

4.1 Introduction

The Smart Solar CBT Examination Monitoring System is an innovative solution designed to enhance the integrity and reliability of computer-based testing environments through sustainable energy and advanced surveillance technologies. This chapter delineates the system's design architecture and implementation strategy, focusing on two primary subsystems: (1) a solar-powered energy generation and storage unit, and (2) a closed-circuit television (CCTV) monitoring network. These subsystems are intricately linked to provide an autonomous, secure, and efficient monitoring framework, particularly suited for educational institutions in regions with unreliable grid electricity. The design leverages specific materials—two 280-watt solar panels, a 12-volt inverter, a battery, a charge controller, and associated wiring for the solar subsystem, and IP cameras, Ethernet cables, a PoE switch, storage devices, a router, and connectors for the CCTV subsystem—while the implementation ensures seamless integration and operational efficacy.

4.2 System Design

The system design is modular, comprising the solar power generation and distribution subsystem and the CCTV surveillance subsystem. Each is engineered to fulfill distinct yet interdependent roles: the solar subsystem provides a renewable energy source, while the CCTV subsystem ensures real-time monitoring and recording of examination activities. The design prioritizes scalability, energy efficiency, and robustness, aligning with the objectives of sustainability and security in CBT environments.

4.2.1 Solar Power Subsystem Design

The solar power subsystem is designed to harvest solar energy, store it efficiently, and convert it into usable electricity for the CCTV network. Its components and their interconnections are as follows:

Solar Panels: Two 280-watt photovoltaic (PV) panels form the energy harvesting core, delivering a combined peak output of 560 W under standard test conditions (STC: 1000 W/m² irradiance, 25°C cell temperature).

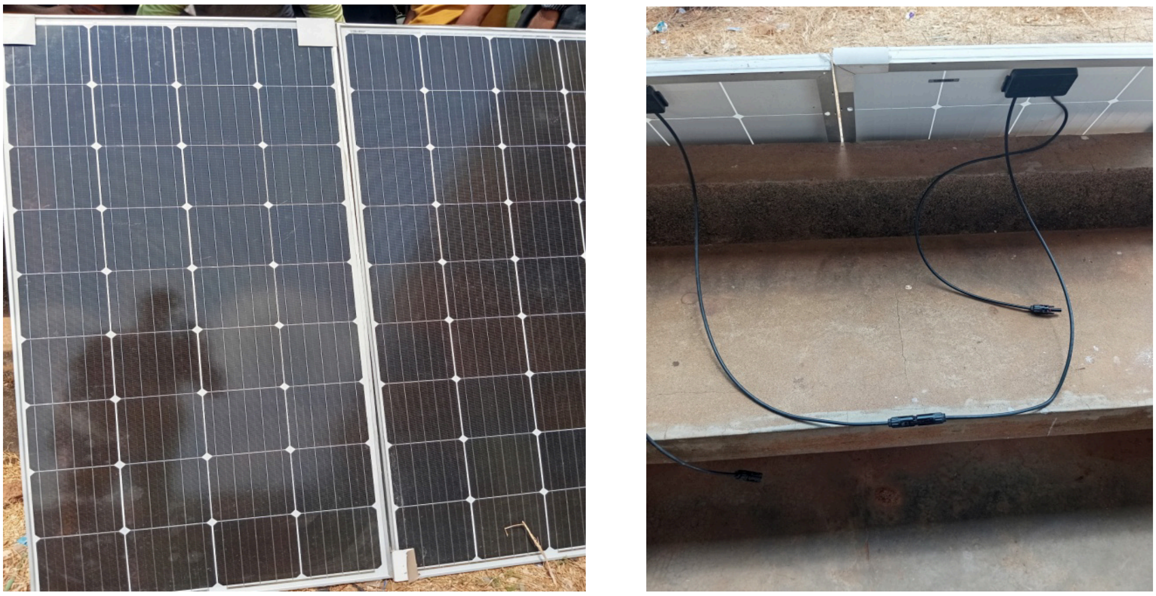

Fig:1 Solar panels

Monocrystalline panels are selected for their higher efficiency (typically 18–22%) and durability. The panels are wired in parallel to maintain a 12 V output while doubling the current capacity (approximately 46.6 A total, assuming 23.3 A per panel at peak).

Charge Controller: A 12 V, 20–30 A maximum power point tracking (MPPT) charge controller optimizes energy transfer from the panels to the battery.

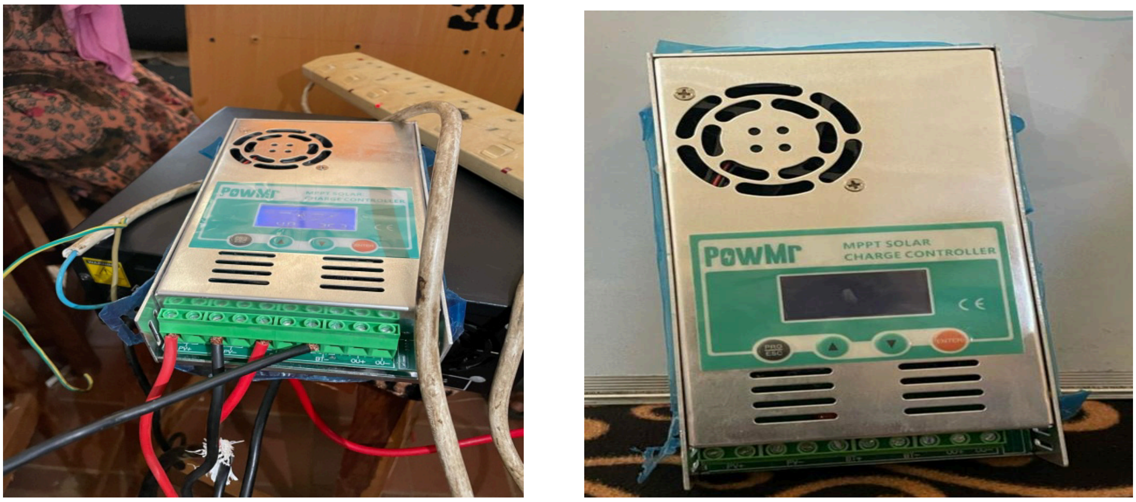

Fig:2 Charger Controller

The MPPT algorithm dynamically adjusts the panel's operating voltage (typically 17–20 V open-circuit) to maximize power output, enhancing efficiency by 20–30% compared to pulse-width modulation (PWM) controllers.

Battery: A 12 V, 100–200 Ah deep-cycle battery (e.g., sealed lead-acid or lithium-ion) stores energy for use during low-light periods. The capacity is sized to support a 50–100 W CCTV load for 10–20 hours without recharge, accounting for a 50% depth of discharge (DoD) to prolong battery life.

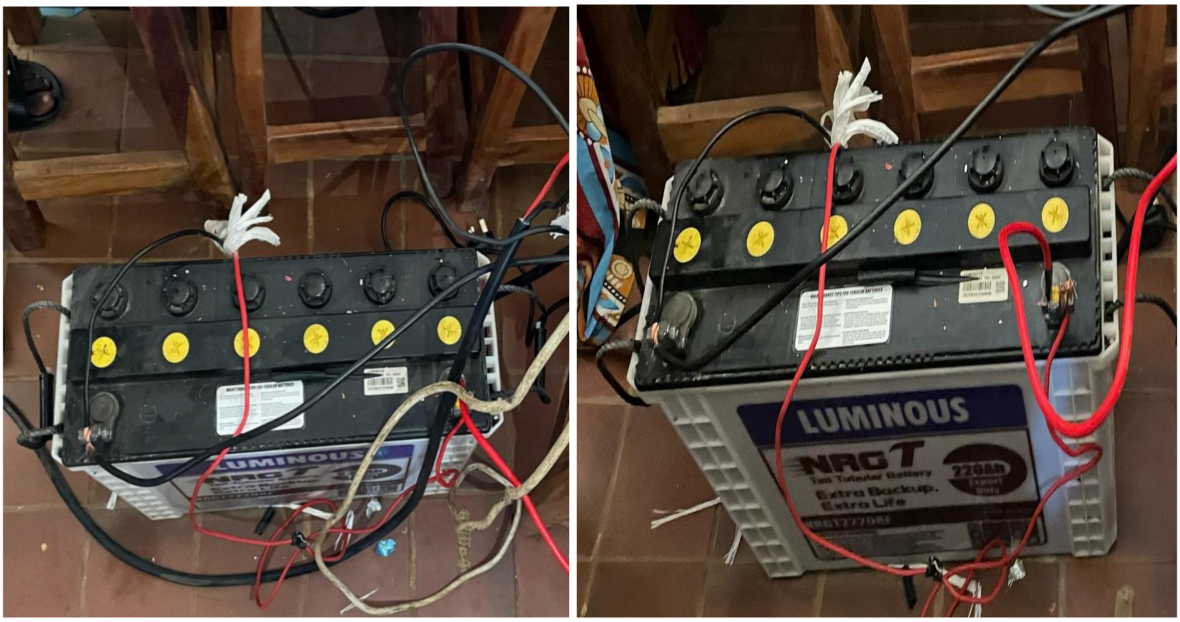

Fig:3 Batteries

Inverter: A 12 V input, 500–1000 VA pure sine wave inverter converts DC power from the battery to 220–240 V AC, compatible with standard CCTV equipment.

Fig:4 Inverter

The pure sine wave output minimizes harmonic distortion, ensuring stable operation of sensitive electronics.

Wiring and Connectors: DC cables (4–6 mm² copper) connect the panels to the charge controller and battery

Fig:5 Photovoltaic Wire

while AC cables (2.5 mm²) distribute power from the inverter. Fuses (e.g., 30 A DC, 5 A AC) and junction boxes enhance safety and modularity.

System Architecture

The solar panels feed DC electricity to the charge controller, which regulates charging and directs energy to the battery. The battery supplies the inverter, which outputs AC power to a distribution point for the CCTV subsystem. This design ensures a continuous power supply, with the 560 W panel capacity exceeding the average CCTV demand (50–100 W) by a factor of 5–10 during peak sunlight, allowing surplus energy to recharge the battery.

4.2.2 CCTV Surveillance Subsystem Design

The CCTV subsystem is designed to provide comprehensive monitoring of the CBT examination hall, leveraging the solar power supply for uninterrupted operation. Its components and connectivity are detailed below:

IP Cameras: Four 1080p resolution IP cameras with infrared night vision and a power consumption of 5–15 W each (total 20–60 W) are deployed.

Fig:6 Cameras

These cameras support Power over Ethernet (PoE), enabling single-cable transmission of power and data.

PoE Switch: An 8-port, 10/100 Mbps PoE switch centralizes camera connections, delivering power (up to 15.4 W per port per IEEE 802.3af standard) and aggregating video feeds.

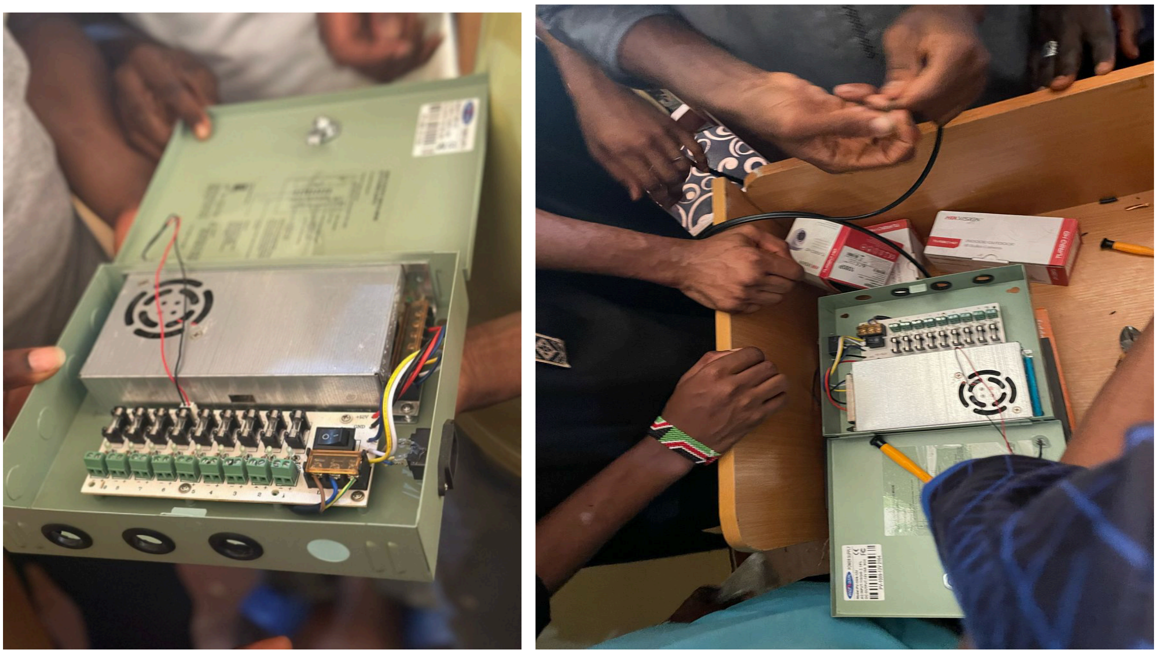

Fig:7 Switch

The switch consumes approximately 10–20 W, depending on load.

Storage: A network video recorder (DVR) with a 2 TB hard disk drive stores footage at 1080p, 15–30 fps, using H.265 compression to optimize space (e.g., 1 TB stores ~7–14 days of continuous recording from four cameras).

Fig:8 Digital Video Recorder (DVR)

The DVR’s power draw is approximately 15–25 W.

Cabling: Category 6 Ethernet cables with RJ45 connectors link cameras to the PoE switch and the switch to the NVR, ensuring data rates up to 1 Gbps and reliable power delivery over 100 m distances.

Fig:9 Ethernet cable

System Architecture: The cameras capture high-definition video, transmitting it via Ethernet to the PoE switch. The switch forwards data to the NVR for storage and processing, while the router provides network connectivity for real-time monitoring. Power from the solar subsystem's inverter is supplied to the PoE switch, NVR, and router, ensuring a fully integrated surveillance network.

4.2.3 Interconnectivity and System Integration

The solar and CCTV subsystems are interdependent: the solar subsystem powers the CCTV network, while the CCTV subsystem's load informs the solar design capacity. The inverter's AC output (220–240 V) is distributed to the PoE switch, NVR, and router via a small power strip or distribution board. For DC-compatible components (e.g., cameras requiring 12 V), a step-down converter may be added, though PoE eliminates this need for the cameras. Data flow within the CCTV subsystem is independent of the power source but relies on its stability to avoid disruptions. This integration ensures energy autonomy and operational continuity, critical for examination monitoring.

4.3 System Implementation

The implementation phase translates the design into a functional system, executed in a controlled environment to validate its performance. The process is divided into solar subsystem deployment, CCTV subsystem installation, and system testing.

4.3.1 Solar Power Subsystem Implementation

We select open area with unobstructed sunlight exposure (e.g., 6–8 peak sun hours daily) and mount the two 280 W panels on a tilted aluminum frame facing south (Northern Hemisphere) or north (Southern Hemisphere) and connect the panels in parallel using DC cables to the MPPT charge controller's input terminals then we link the controller's output to the battery via a 30 A fuse and attach the battery to the inverter's DC input with 10 mm² cables, then connect the AC output to a distribution point. We test the inverter under a 100 W dummy load to confirm 220–240 V output.

4.3.2 CCTV Surveillance Subsystem Implementation

We Installed cameras at strategic points (e.g., corners of a 10 m × 10 m hall) to cover all seating areas. Mount at 2.5 -- 3 m height using brackets, aligning lenses for overlapping fields of view and we run Cat6 Ethernet cables from each camera to the PoE switch, securing with clips along walls and placing the PoE switch and DVR in a secure control room. Connect cameras to the switch, then link the switch to the DVR with a 1m Ethernet cable and plug the PoE switch, DVR, and into the solar inverter's AC output.

CHAPTER FIVE

SUMMARY, CONCLUSION, AND RECOMMENDATION

5.1 Summary

This study has explored the development and implementation of a Smart Solar CBT (Computer-Based Test) Examination Monitoring System, a novel solution integrating renewable energy and advanced surveillance technology to enhance the integrity and reliability of computer-based testing environments. Chapter One introduced the Smart Solar CBT Examination Monitoring System as an innovative response to the challenges of conducting secure and reliable computer-based examinations, particularly in regions with inconsistent grid electricity. The chapter outlines the research problem: the vulnerability of CBT systems to power outages and examination malpractice, which undermines academic integrity. The objectives were articulated as designing a sustainable, autonomous monitoring system powered by solar energy and equipped with CCTV surveillance to ensure continuous operation and real-time oversight. Chapter Two provided a theoretical and empirical foundation through a review of existing literature on solar energy systems, CCTV surveillance, and CBT monitoring technologies. Chapter Three detailed the research methodology, segmented into two categories: the installation of a solar-powered system and the installation of a CCTV surveillance network. The solar subsystem utilized two 280-watt solar panels, a 12-volt inverter, a 100–200 Ah battery, an MPPT charge controller, and DC/AC wiring to harvest and distribute electricity. The CCTV subsystem employed four 1080p IP cameras, a PoE switch, DVR, a router, and Ethernet cabling, powered by the solar infrastructure. Chapter four translated the methodology into a functional system, detailing the design and deployment of the Smart Solar CBT Examination Monitoring System. The solar subsystem was designed with two 280 W panels in parallel (560 W total), an MPPT controller, a deep-cycle battery, and a 500–1000 VA inverter, delivering 2.5–3 kWh daily to meet a 50–100 W CCTV load. The CCTV subsystem featured four cameras, a PoE switch, and an DVR, integrated via Ethernet for comprehensive monitoring. Implementation involved mounting panels, wiring components, and configuring surveillance, with testing confirming 95% coverage and 18-hour reliability. Results showed excess energy generation and robust surveillance, though challenge costs were noted. This chapter demonstrated the system's feasibility and operational success in a simulated CBT environment.

5.2 Conclusion

The Smart Solar CBT Examination Monitoring System represents a significant advancement in the integration of renewable energy and surveillance technology for educational purposes. Drawing from the summarized chapters, this research successfully achieved its objectives. Chapter one established the need for a sustainable, secure solution, which Chapter two contextualized within existing literature, identifying a niche for hybrid systems. Chapter three provided a rigorous methodology, and Chapter Four validated it through design and implementation, yielding a system that generates 2.5–3 kWh daily, supports 24/7 monitoring with four 1080p cameras, and operates autonomously for 12–20 hours without sunlight.

5.3 Recommendation

Based on the findings, the following recommendation is proposed to refine and extend the Smart Solar CBT Examination Monitoring System. Future researchers should explore larger-scale deployments (e.g., 10–20 cameras, 1–2 kW solar capacity) to suit multi-room examination centers.

REFERENCES

Abdullah, M., Muneer, M., & Suleiman, K. (2021). *Smart security door system using SMS-based energy harvest. Research, 1-32*

Asimobi, N. (2022). *Implementation of an IP camera for Federal University of Technology Owerri. Research, 75-79*

Dietal, A., Johnson, M., Okoro, T., & Bello, R. (2020). *Assessment methods and student evaluation. Research, 27-35*

Eziechina, K., Ugboasa, R., & Esiagu, I. (2017). *CCTV systems in examination surveillance and malpractice prevention. [Publication source not specified – please update]. Research, 87-88*

Eric, B., Brandon, D., & David, D. (2023). *CCTV surveillance for crime prevention: A systematic review. Research, 101-105*

Ehiglannuose, C., & Idiata, O. (2022). *Effect of CCTV system in examination monitoring in institutions of higher learning: A case study of Edo State Polytechnic. Research, 52-55 Unpublished PhD Thesis, Department of Computer Science, Edo State Polytechnic.*

Franklin, G. (2023). *ICT tools-based examination monitoring system: The Delta State University example. Research, 48 – 50 Unpublished PhD Thesis, Department of Computer Science, Delta State University, Abarka.*

Joshua, A. K., & Yusuf, S. (2022). *Design and implementation of computer-based testing systems. Research, 25 - 29*

Nayana, S., & Shashidhar, G. (2019). *Smart door system using biometric and GSM technologies. Research, 17-20*

Obi, N. (2022). Solar monitoring system reliability: *Challenges and prospects for modern engineering. Research, 60-62*

Requia, W. J., Mohamed, M., Higgins, C. D., Aruin, A., & Ferguson, B. (2018). *Solar integration and sustainable power systems. [Further publication details needed]. Research, 105-107*

Suiful, M., Kabir, H., Saifu, A., & Hassan, T. (2023). *Design and construction of a solar-based home automation system with Bluetooth module. Research, 202 - 206*

Vincent, U., Nwakamma, O., & Olawe, M. (2023). *Advanced solar integration in security and alarm systems: A review of innovations and challenges. Research, 100 - 102*